National Aeronautics and Space Administration

NASA-DoD Lead-Free Electronics Project

DoD Soldering Technologies Working Group (STWG)

August 24 - 25, 2010

www.nasa.gov

Resources

Project documents, test plans, test reports and other associated information will be available on the web:

- NASA-DoD Lead-Free Electronics Project: http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html
  - Joint Test Protocol
  - Project Plan
  - Test Reports

Project Stakeholders

U.S. AIR FORCE

DEFENSE MICROELECTRONICS ACTIVITY
UNITED STATES OF AMERICA

NASA

NAVSEA
WARFARE CENTERS
CRANE

Rockwell Collins

BAE SYSTEMS

LOCKHEED MARTIN
We never forget who we're working for™

NIHON SUPERIOR

BOEING

CELESTICA

Raytheon

Sandia National Laboratories

GENERAL DYNAMICS
Advanced Information Systems

calce

Honeywell

HARRIS

TEXAS INSTRUMENTS

COM DEV

Premier
SEMICONDUCTOR SERVICES, LLC

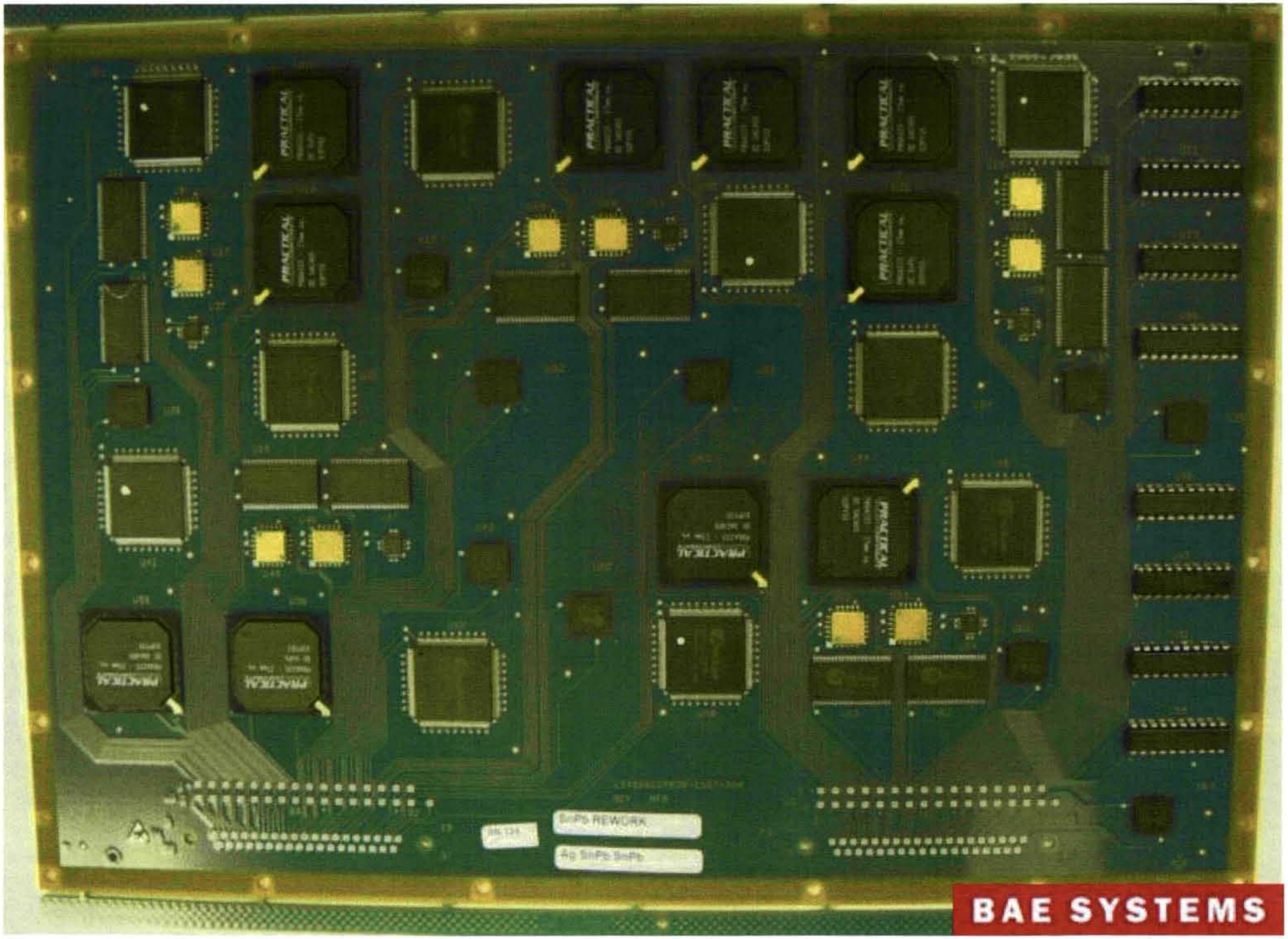
ITB-inc.

Interconnect PWB Solutions Inc.

Scorpio Solutions

Test Vehicles

- 193 Test Vehicles Assembled by BAE Systems (Irving, Texas)
  120 = "Manufactured"
  73 = "Rework"

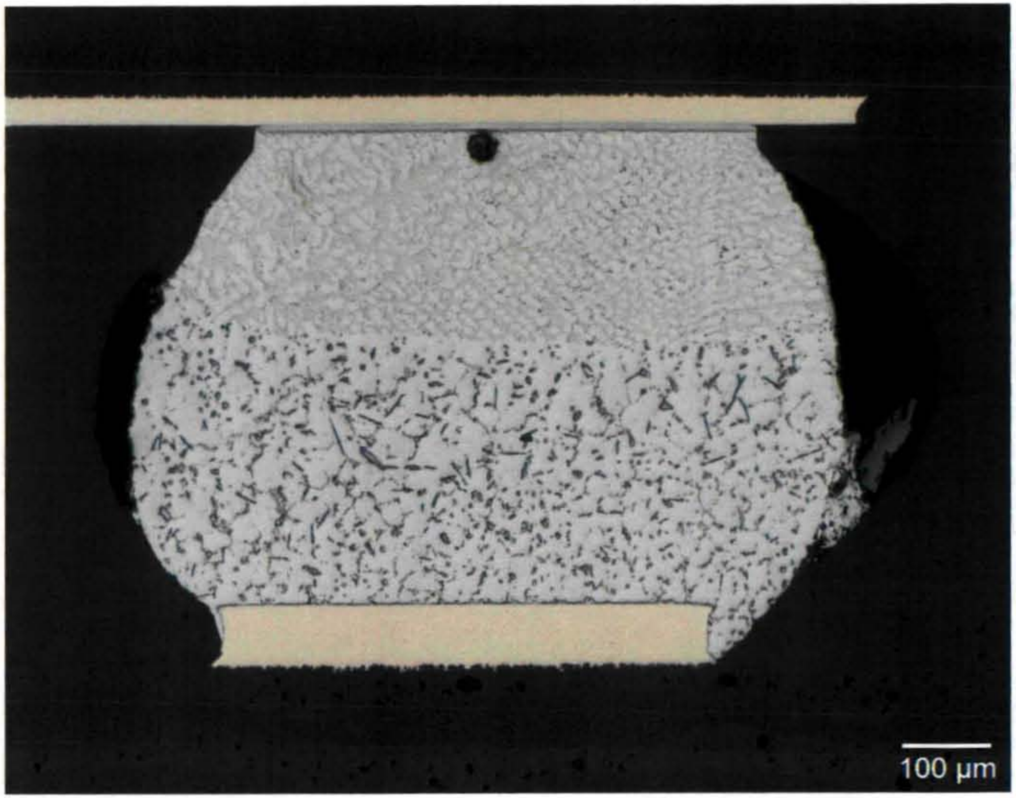


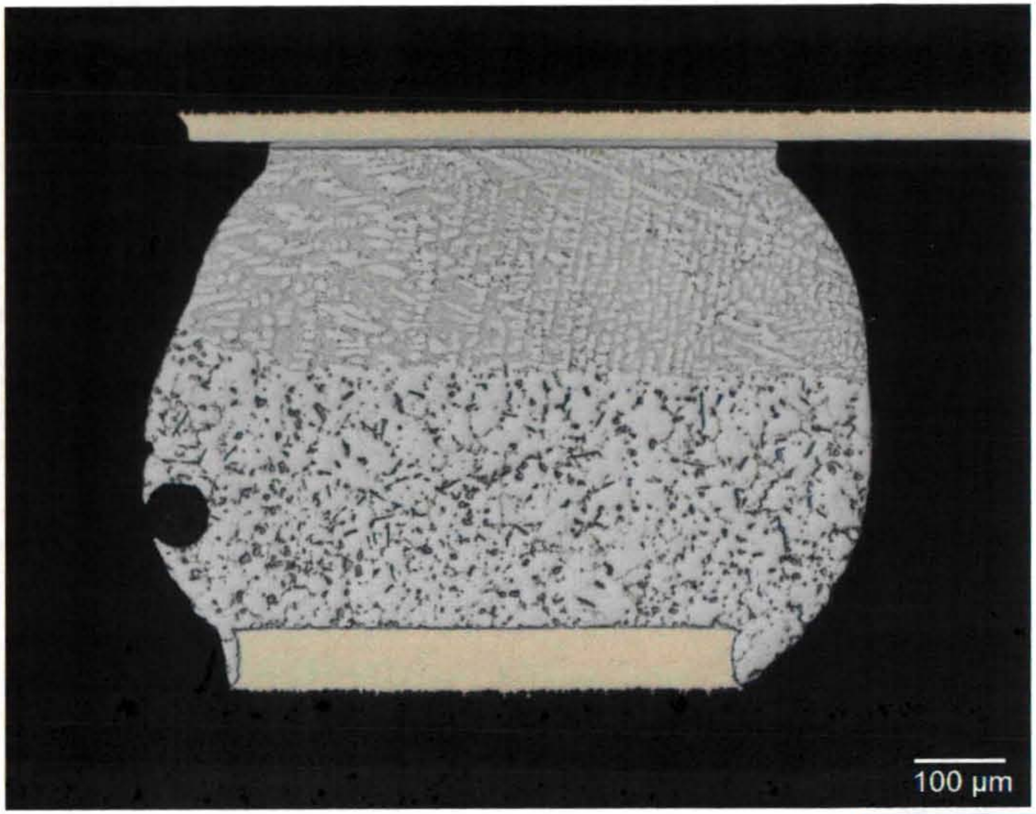
Circuit Cards

- 14.5"X 9"X 0.09"
- 6 layers of 0.5 ounce copper
- FR4 per IPC-4101/26 with a minimum Tg of 170ºC (Isola 370HR)
- Pho-Tronics

Test Vehicle Characterization

Board # 3 SnPb As Fabricated
U18-BGA-225
Component Finish: SAC405, Reflow: SnPb



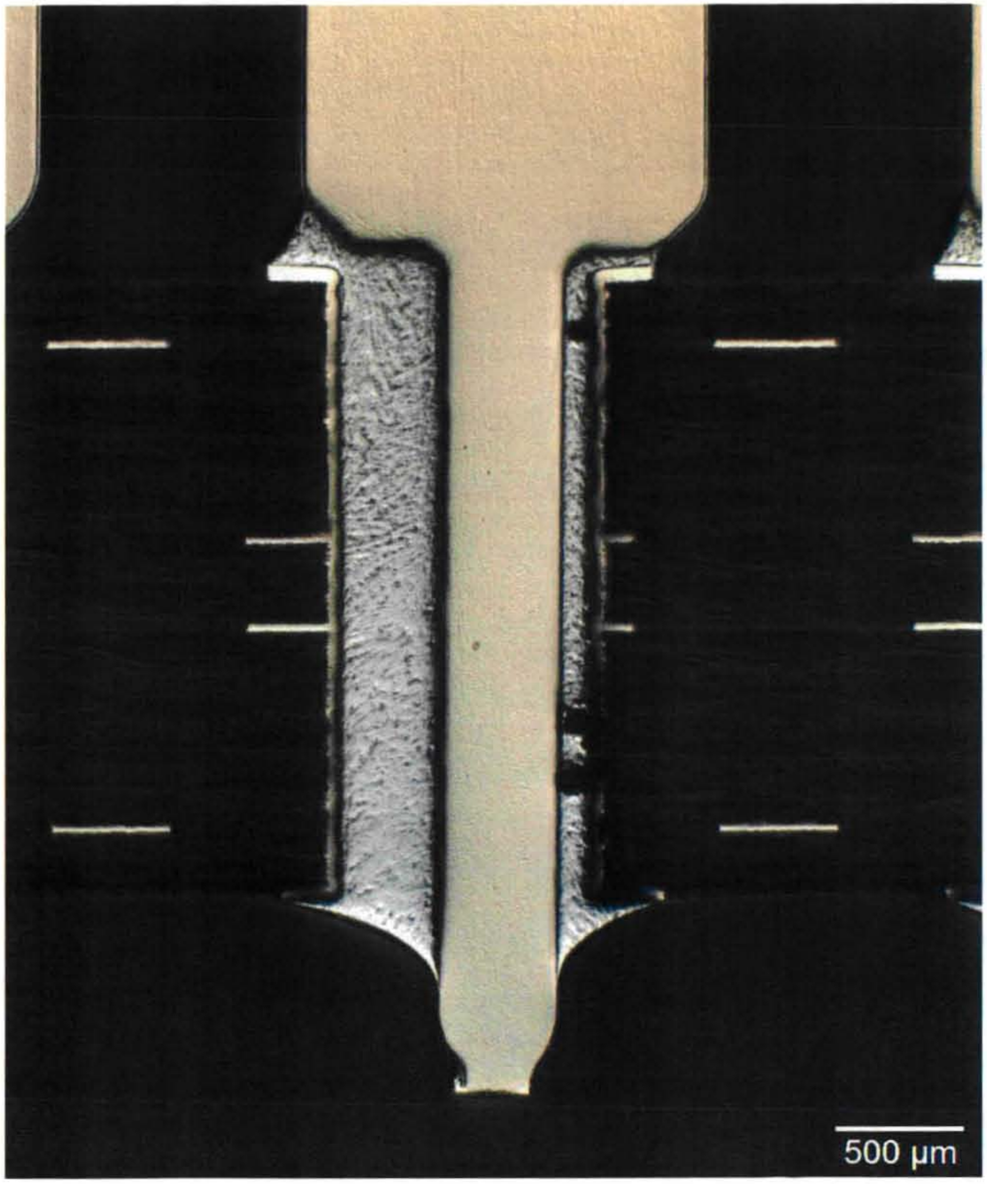


Reflow Soldering
Location – BAE Systems Irving, Texas
Reflow Profile = SnPb

- Preheat = ~ 120 seconds @140-183°C
- Solder joint peak temperature = 225°C
- Time above reflow = 60-90 sec
- Ramp Rate = 2-3 °C/sec

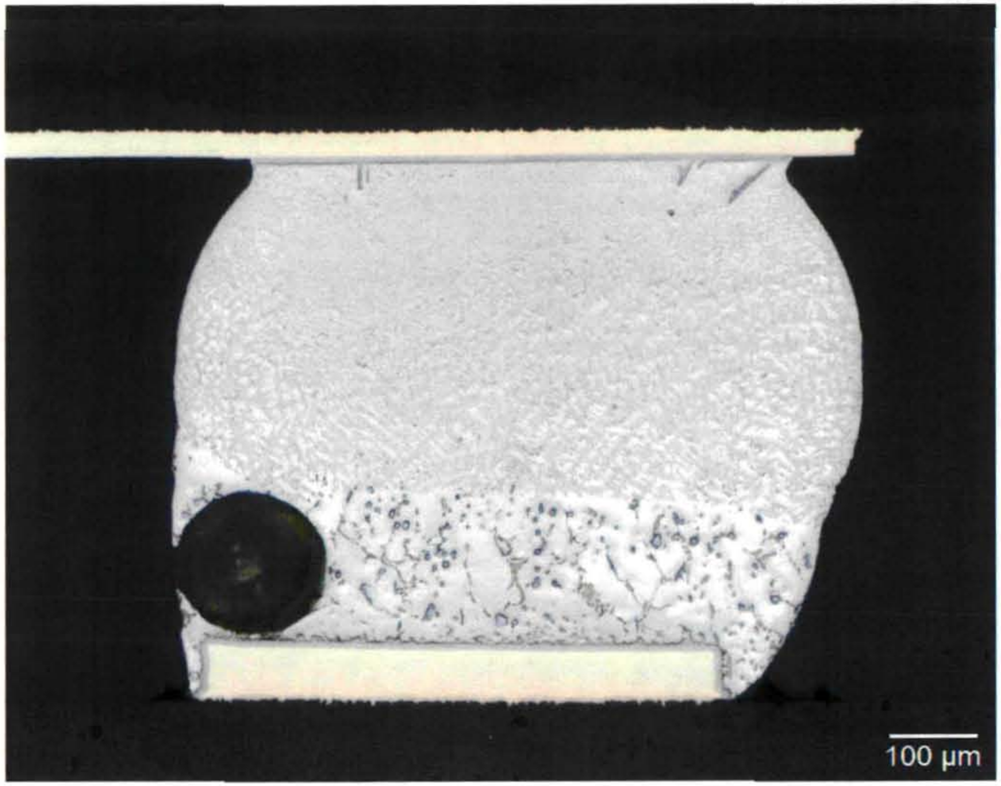
Test Vehicle Characterization

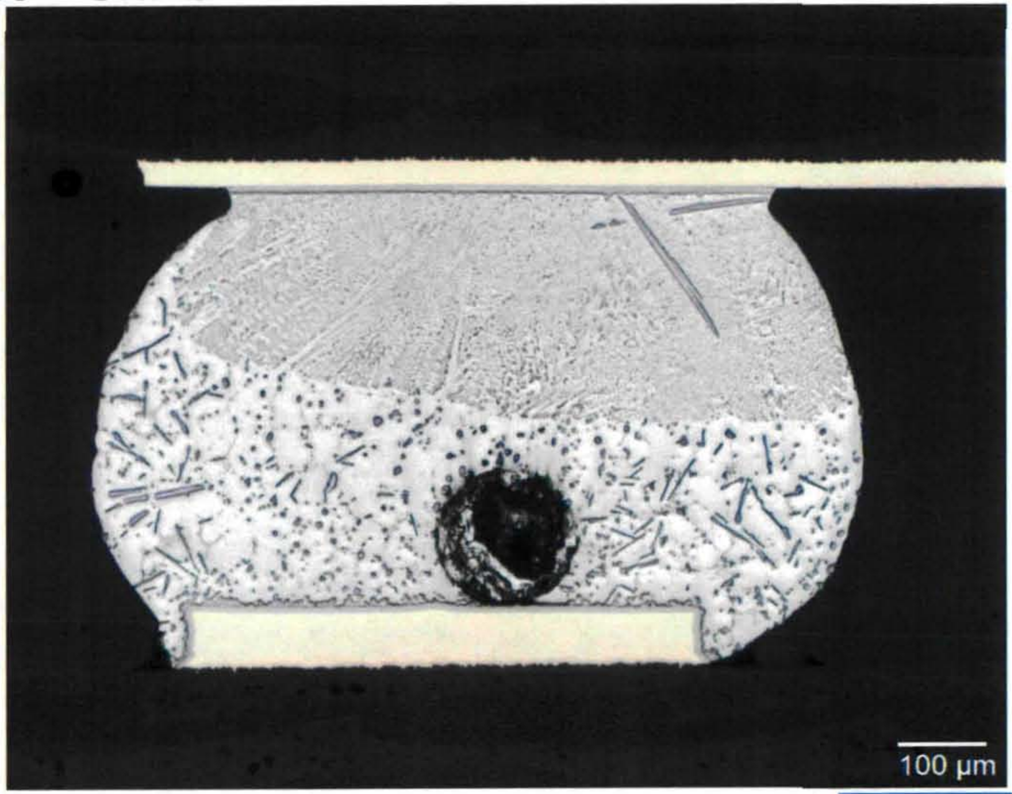
Board # 3 SnPb As Fabricated
U51-2 PDIP-20
Component Finish: Sn, Wave: SnPb



Test Vehicle Characterization

Board # 154 SnPb Rework
U18 BGA-225
As assembled - Component Finish: SnPb, Reflow: SnPb
Reworked - Component Finish: SAC405, Rework Solder: SnPb
Rework Profile - SnPb





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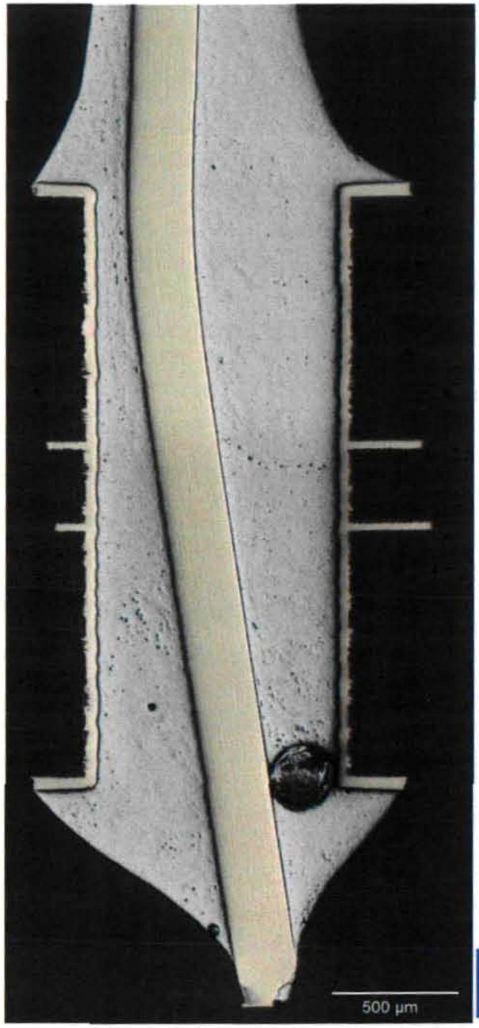
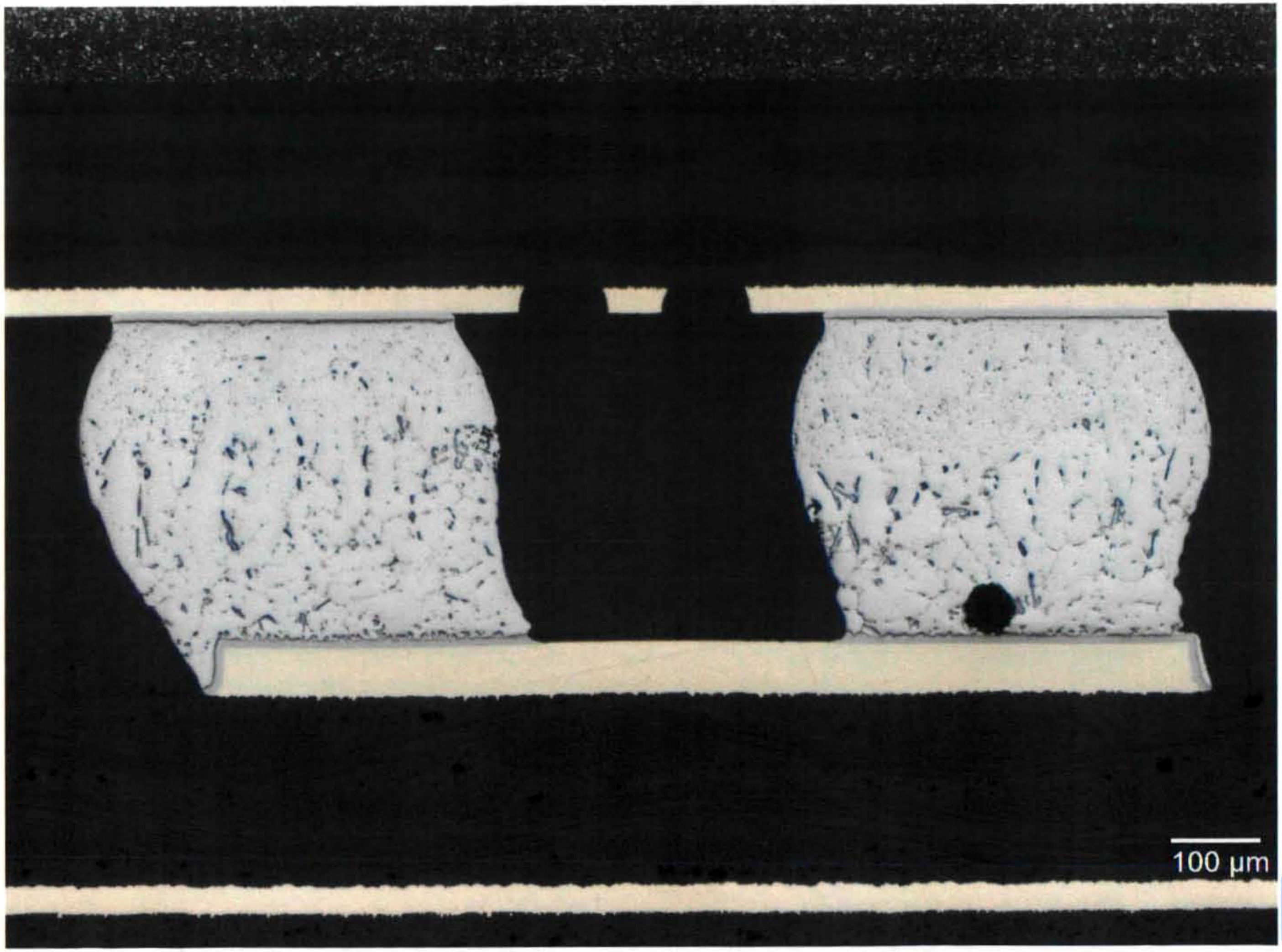
Test Vehicle Characterization

Board # 154 SnPb Rework
U51-1 PDIP-20
Component Finish: SnPb, Wave: SnPb
Reworked - Component Finish: Sn, Rework Solder: SnPb
Rework Profile - SnPb



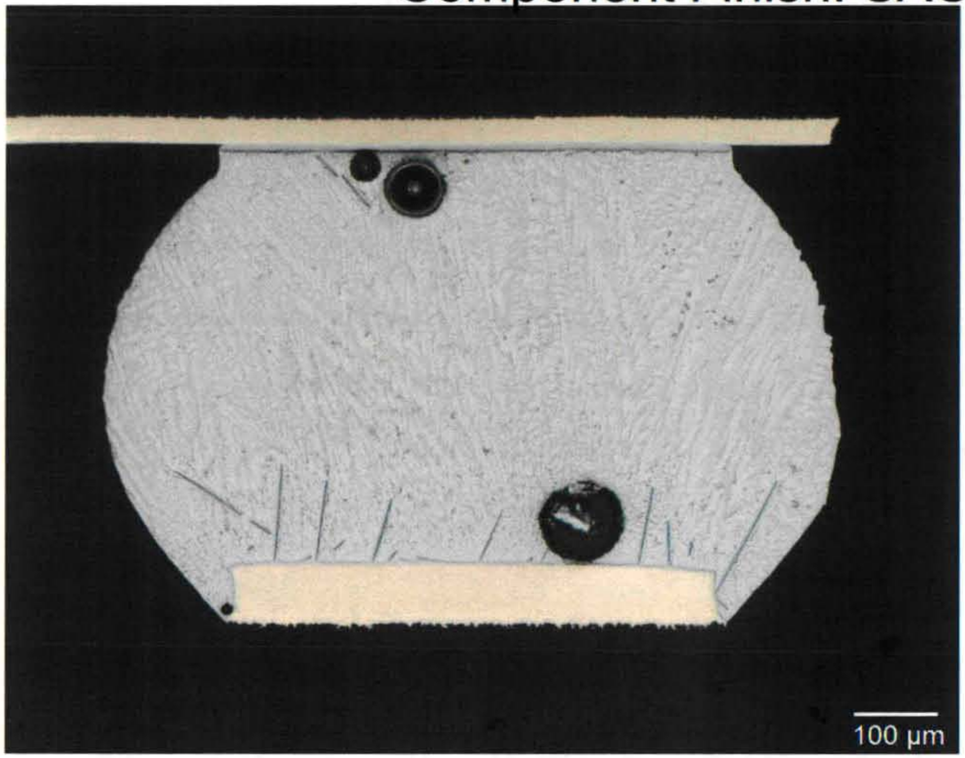
Test Vehicle Characterization

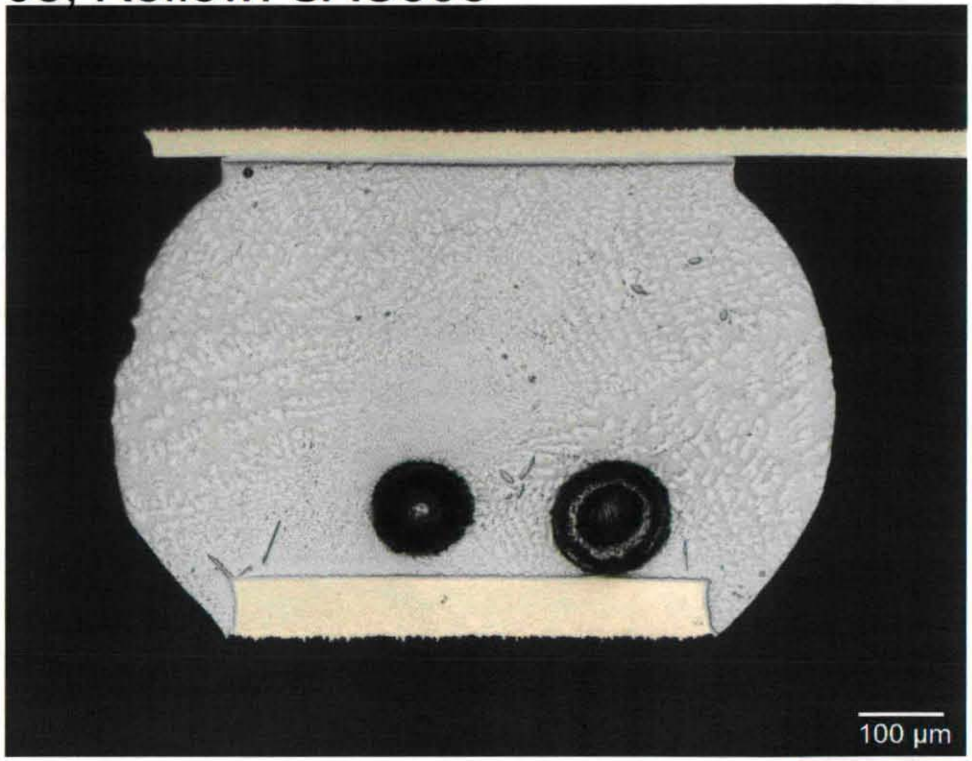
Board # 154 SnPb Rework
U60 CSP-100
Component Finish: SnPb , Reflow: SnPb
Reworked - Component Finish: SAC105, Rework Solder: SnPb
Rework Profile - SnPb



Test Vehicle Characterization

Board # 39 Lead Free As Fabricated
U2 BGA-225
Component Finish: SAC405, Reflow: SAC305





Reflow Soldering
Location – BAE Systems Irving, Texas
Reflow Profile = SAC305

- Preheat = 60-120 seconds @150-190°C
- Peak temperature target = 243°C
- Reflow:~20 seconds above 230°C
- ~30-90 seconds above 220°C

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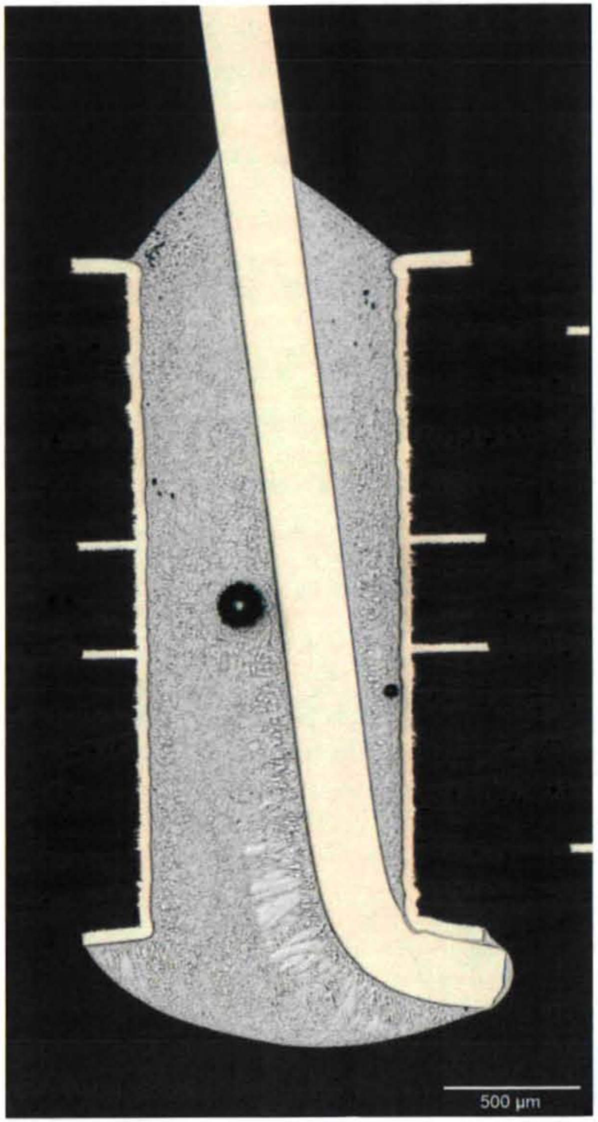
Test Vehicle Characterization

Board # 39 Lead Free As Fabricated
U51-1 PDIP-20
Component Finish: NiPdAu, Wave: SN100C



Sandia National Laboratories

NAVSEA Crane Rework Effort

Built 30 test vehicles (sub-set of the 193 assembled)

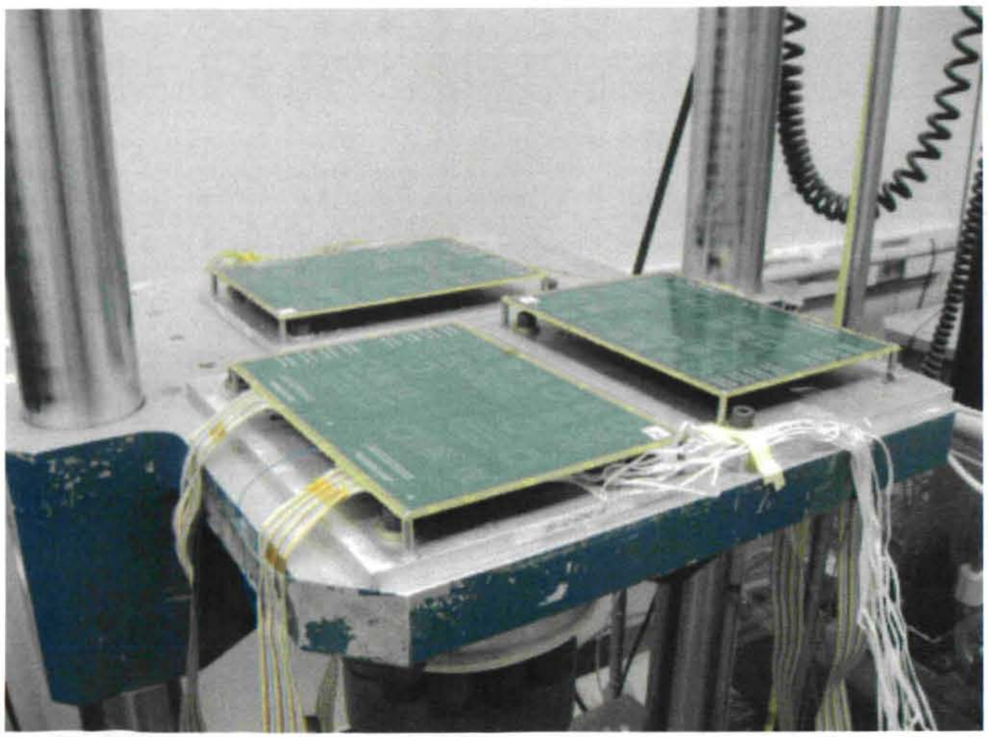
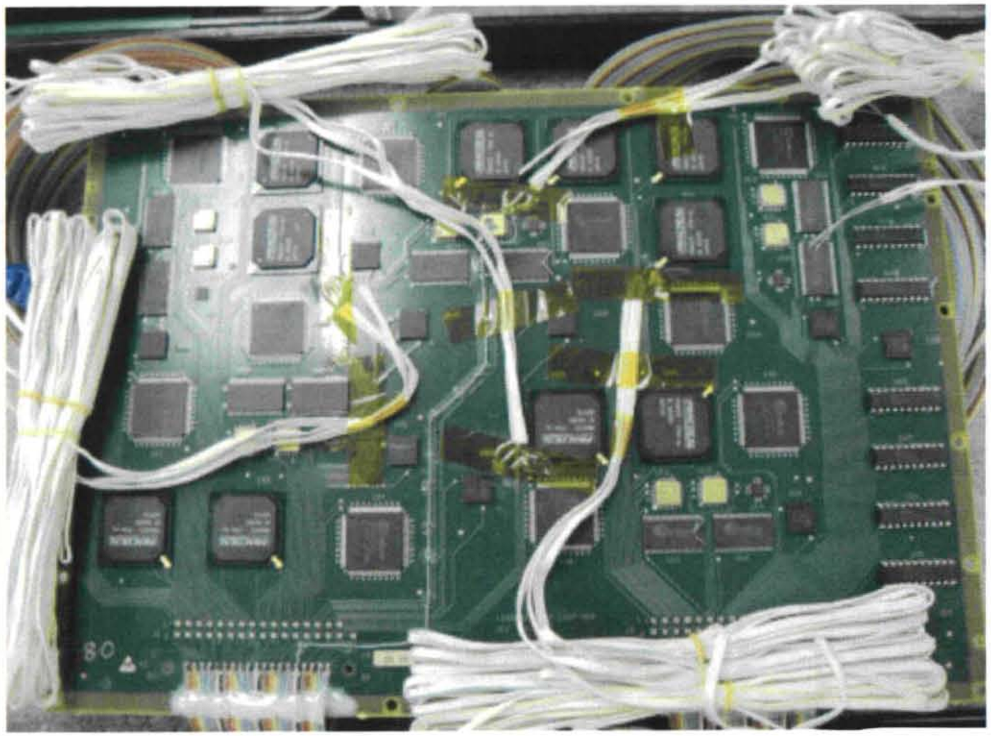
- Test vehicles were built with Lead-Free solder and Lead-Free component finishes only = similar to Manufactured test vehicles for Mechanical Shock, Vibration and Drop Testing
- Lead-Free alloys, SAC305 and SN100C
- Rework was done using only SnPb solder
- Performed multiple pass rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components
- Testing
  - Thermal Cycling -55°C to +125°C Rockwell Collins **COMPLETE**
  - Vibration Testing CELESTICA **COMPLETE**
  - Drop Testing CELESTICA **COMPLETE**

http://teerm.nasa.gov/NASA_DODLeadFreeElectronics_Proj2.html

Drop Testing

NSWC Crane Test Vehicles

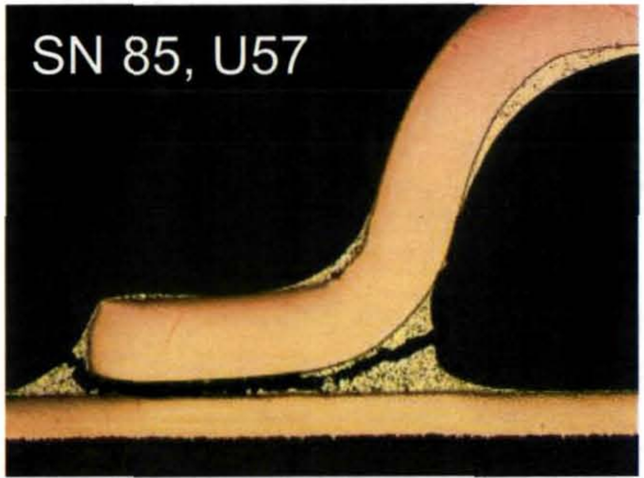
- Shock parameters: 500 G, 2.0 ms duration (340 G for cards 80, 82, 87 for first
- 10 drops)
- Number of drops: 20
- 9 cards in total / 3 cards tested per drop
- Each card monitored for shock response
- Each card monitored for resistance
- Cards 80, 83, 86 monitored for strain

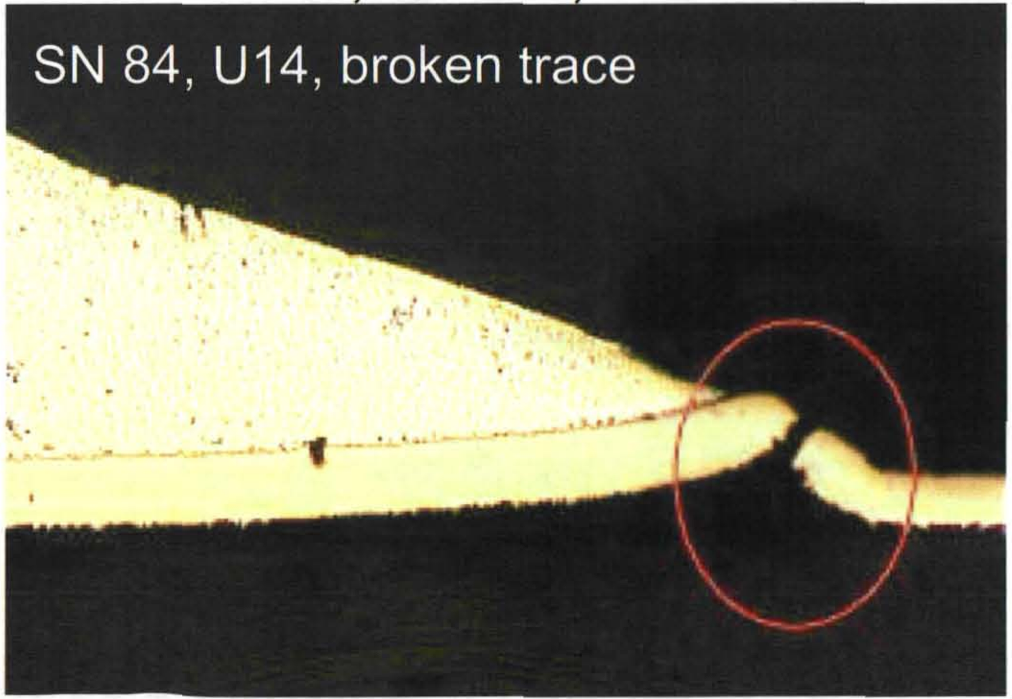



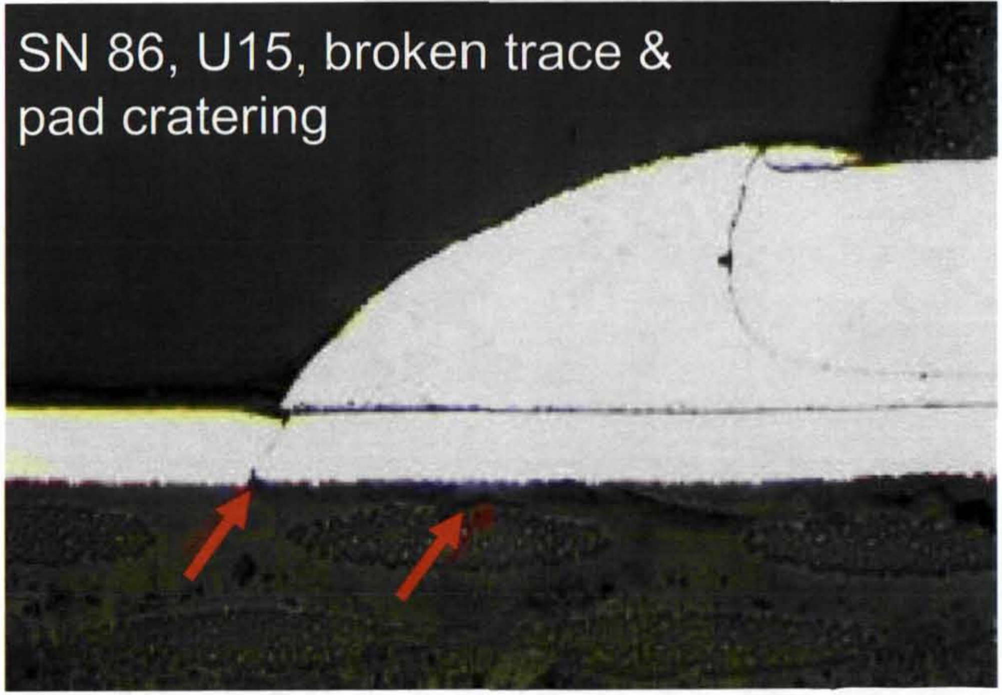
Drop Testing

NSWC Crane Test Vehicles

- Only component to have significant failures – BGA 225
- The 4 non-BGA samples that had an electrical failure had the following rework histories:
  - SN 85, TQFP 144, U57 was reworked once
  - SN 85, PDIP-20, U8 was reworked once
  - SN 84, CLCC-20, U14 was not reworked
  - SN 86, QFN-20, U15 was reworked twice



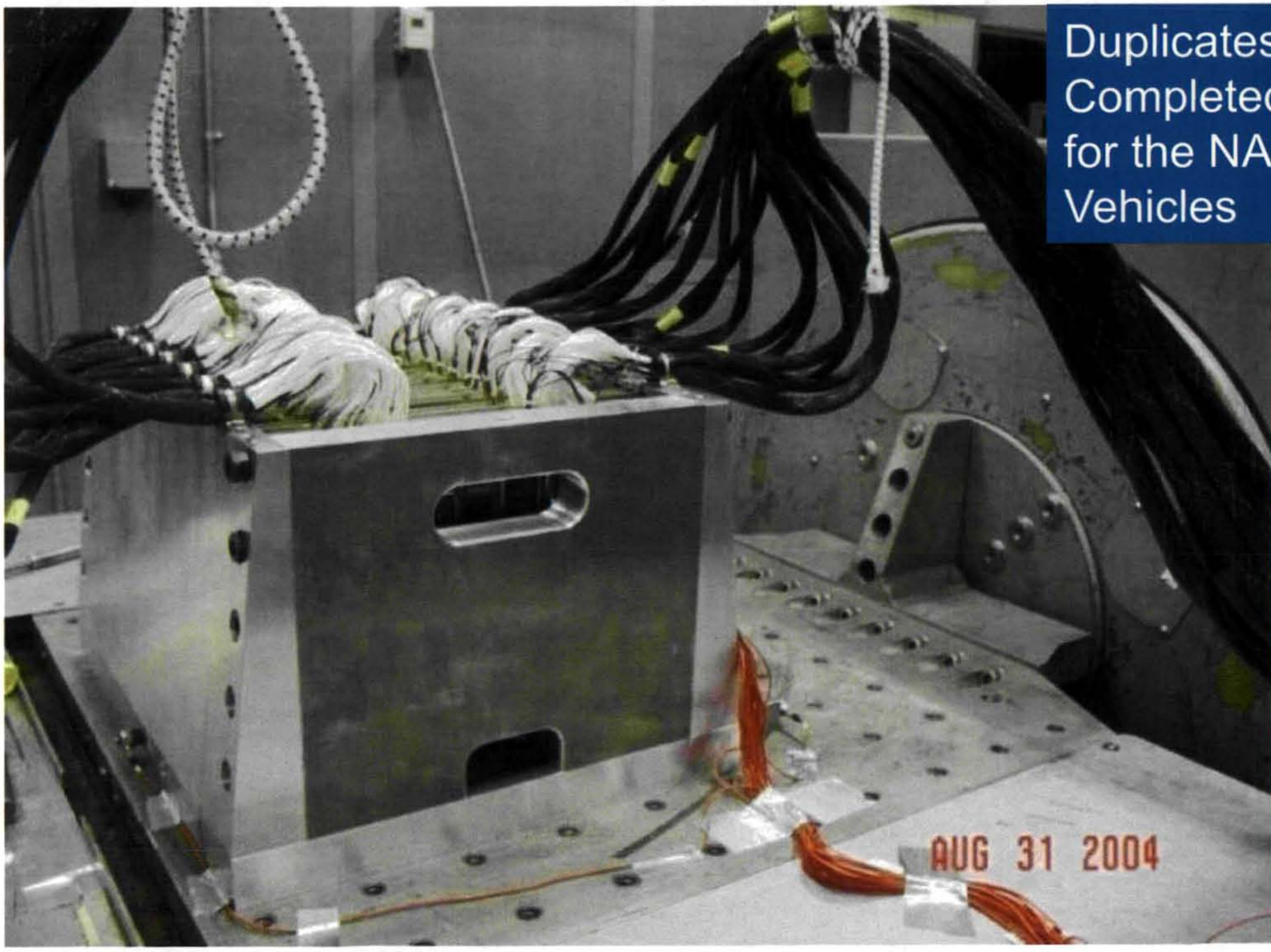




Vibration Testing

CELESTICA

Subject the test vehicles to 8.0 g_{rms} for one hour. Then increase the Z-axis vibration level in 2.0 g_{rms} increments, shaking for one hour per step until the 20.0 g_{rms} level is completed. Then subject the test vehicles to a final one hour of vibration at 28.0 g_{rms}.



Duplicates Testing Completed by Boeing for the NASA-DoD Test Vehicles

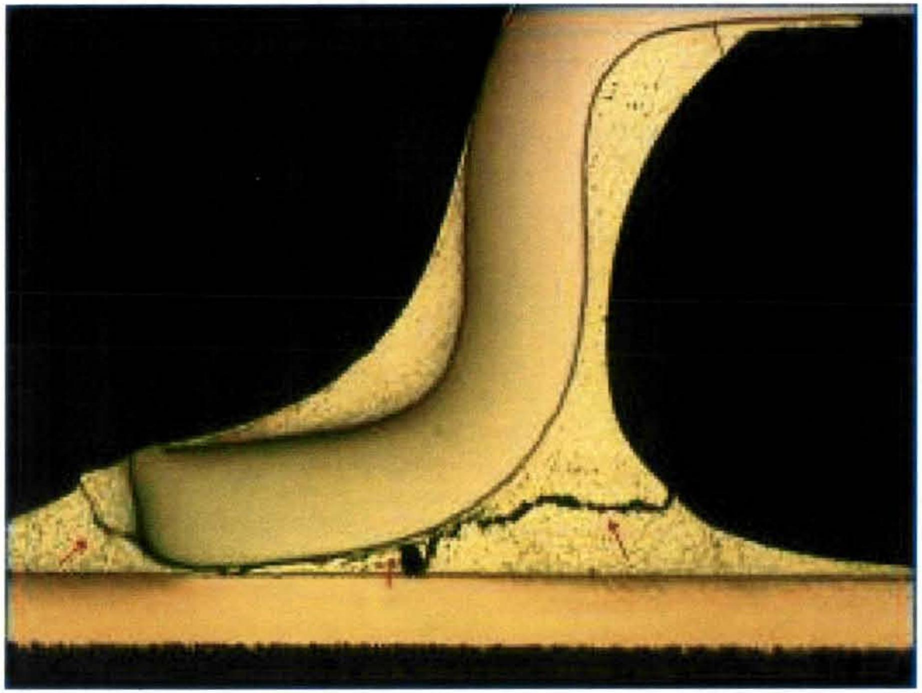
Vibration Testing

CELESTICA

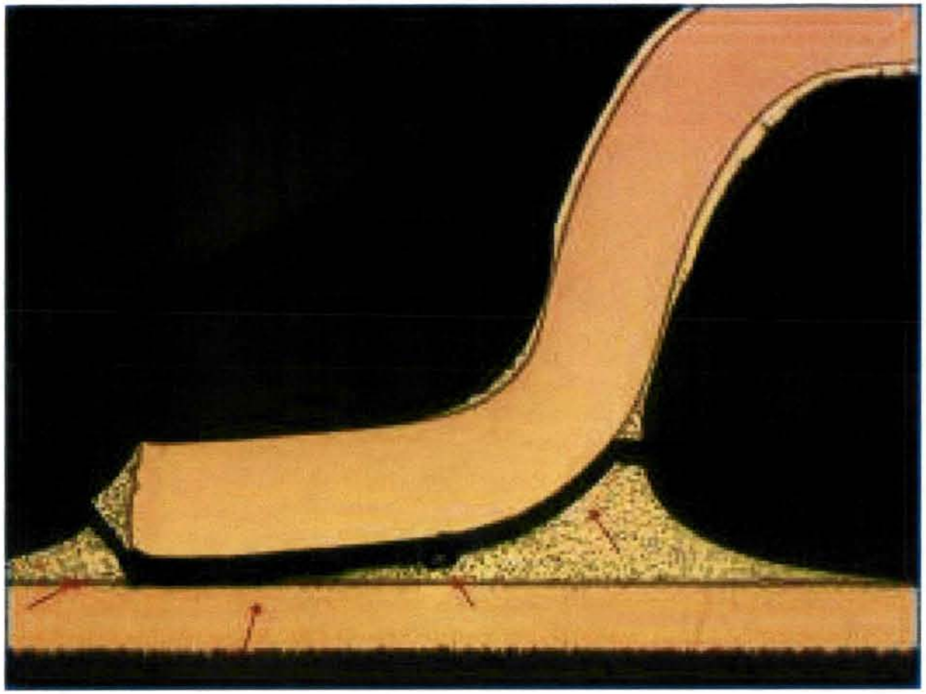
- Among the parameters tested, unexplained variation continues to dominate the results
  - Batch or Card S/N did not significantly influence the results
  - Component package style had a marked influence on both the time to failure (Tf) and on the number of cycles to 10% failure (N10)
- Rework
  - Did influence time to failure
  - Did not significantly influence N10
- Location on the board
  - Did significantly influence time to failure
  - Did not significantly influence N10

Vibration Testing

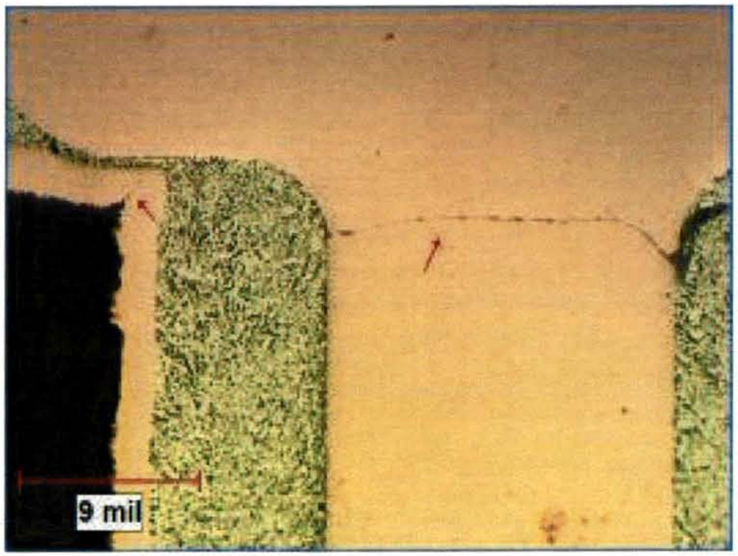
CELESTICA



SN67, U61, left lead solder crack, 100x



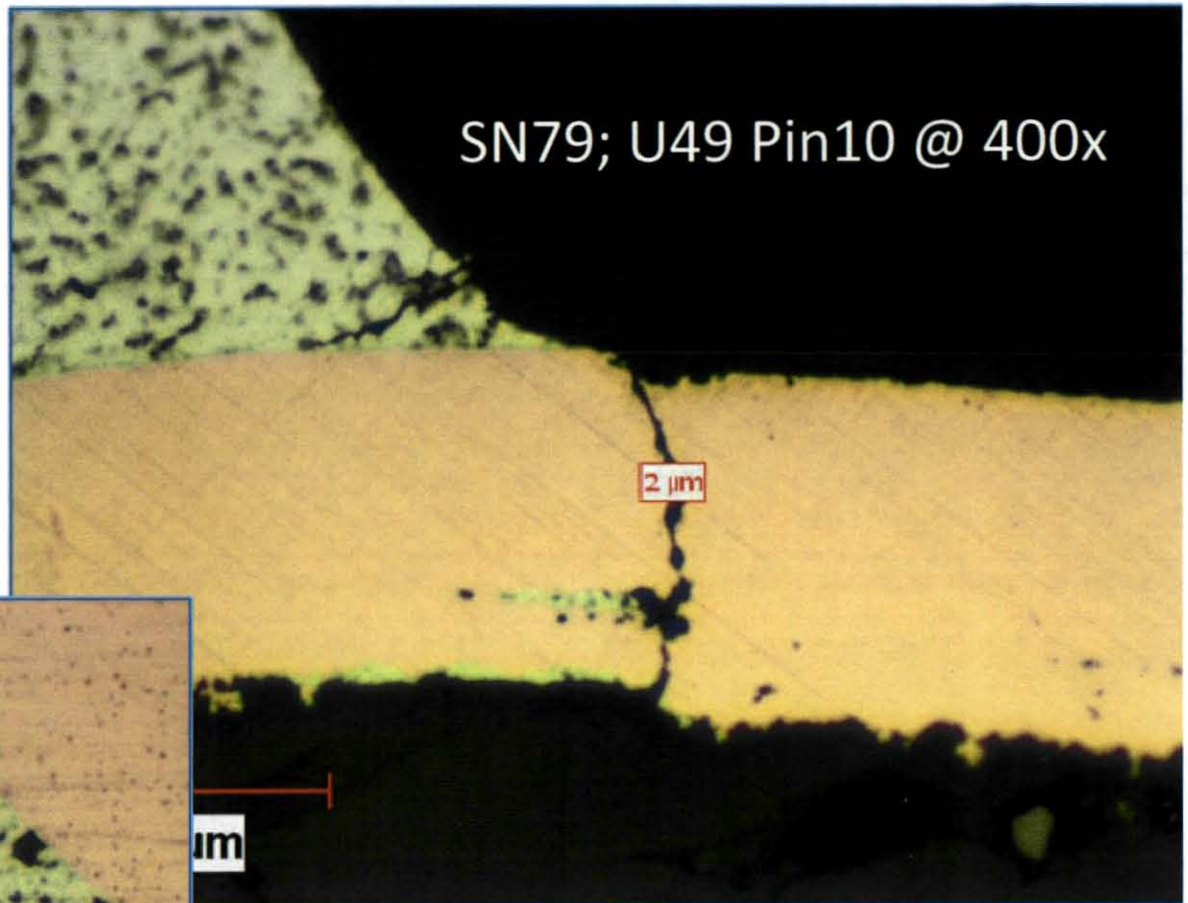
SN67, U31, left lead solder crack, 100x

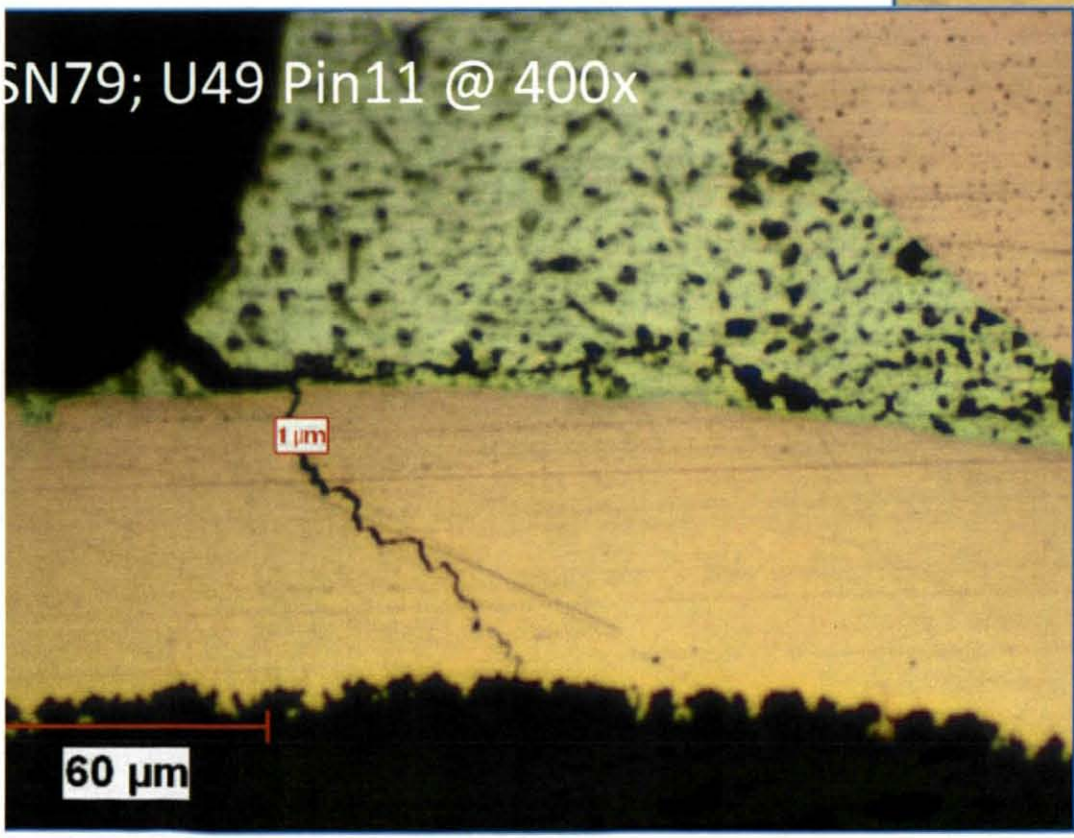


SN 79, U49, pin 11, 100x

Vibration Testing

CELESTICA





Testing Activities
NASA-DoD Test Vehicles

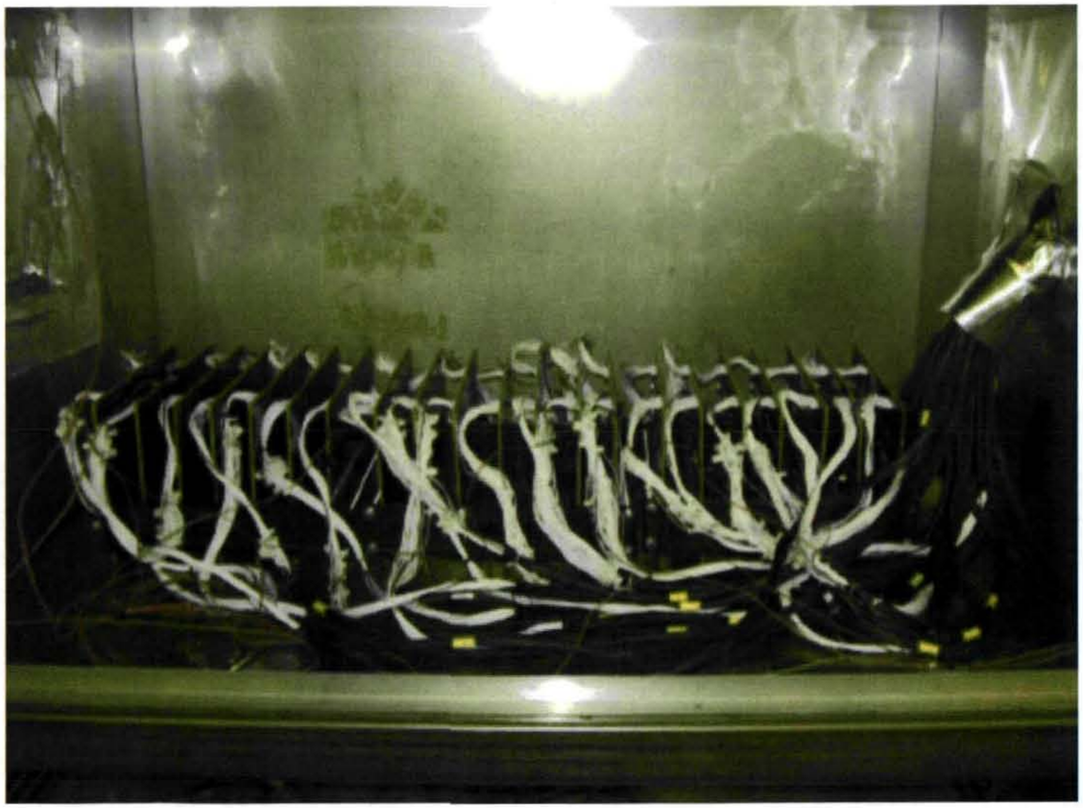
Specific testing details can be found in the Joint Test Protocol (JTP)
http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html

- Thermal Cycle Testing (-20/+80°C) BOEING
- Combine Environments Testing Raytheon COMPLETE
- Drop Testing CELESTICA COMPLETE
- Thermal Cycle Testing (-55/+125°C) Rockwell Collins COMPLETE
- Vibration Testing BOEING COMPLETE
- Mechanical Shock Testing BOEING COMPLETE
- Interconnect Stress Test (IST) Interconnect PWB Solutions Inc. COMPLETE
- Copper Dissolution CELESTICA Rockwell Collins

Thermal Cycle Testing ($-20/+80^oC$)

Test Parameters

- 5 to 10^oC/minute ramp
- 30 minute dwell at 80^oC
- 10 minute dwell at -20^oC



~ 7,000 Thermal Cycles Completed

Thermal Cycle Testing (-55/+125°C)

Rockwell Collins

Test Parameters

- 5 to 10°C/minute ramp
- 30 minute dwell at 125°C
- 10 minute dwell at -55°C

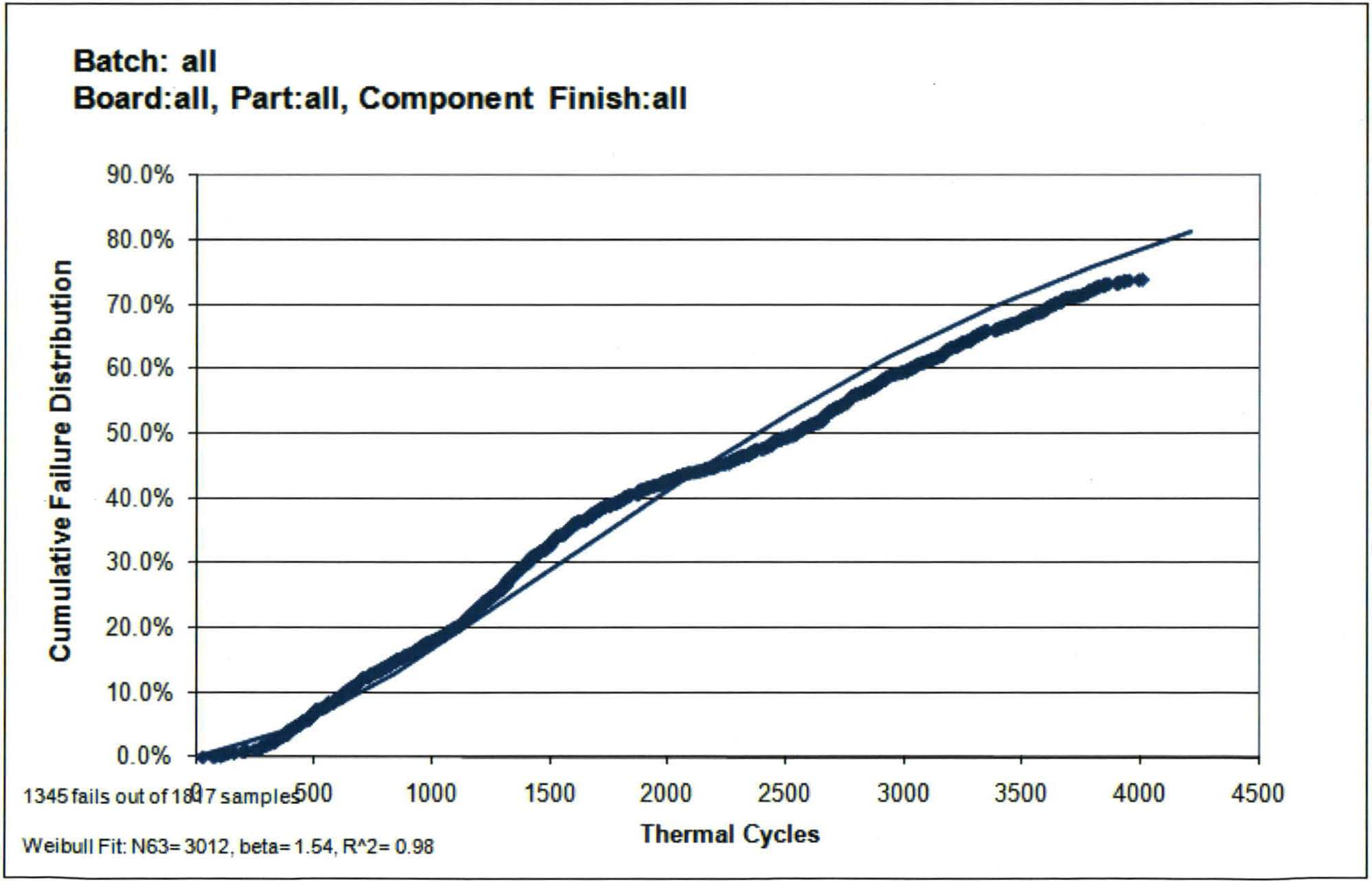
~4,000 Thermal Cycles Completed

Thermal Cycle Testing (-55/+125°C)

Rockwell Collins

Data Snapshot from "Manufactured" Test Vehicles

- No "Rework" Data

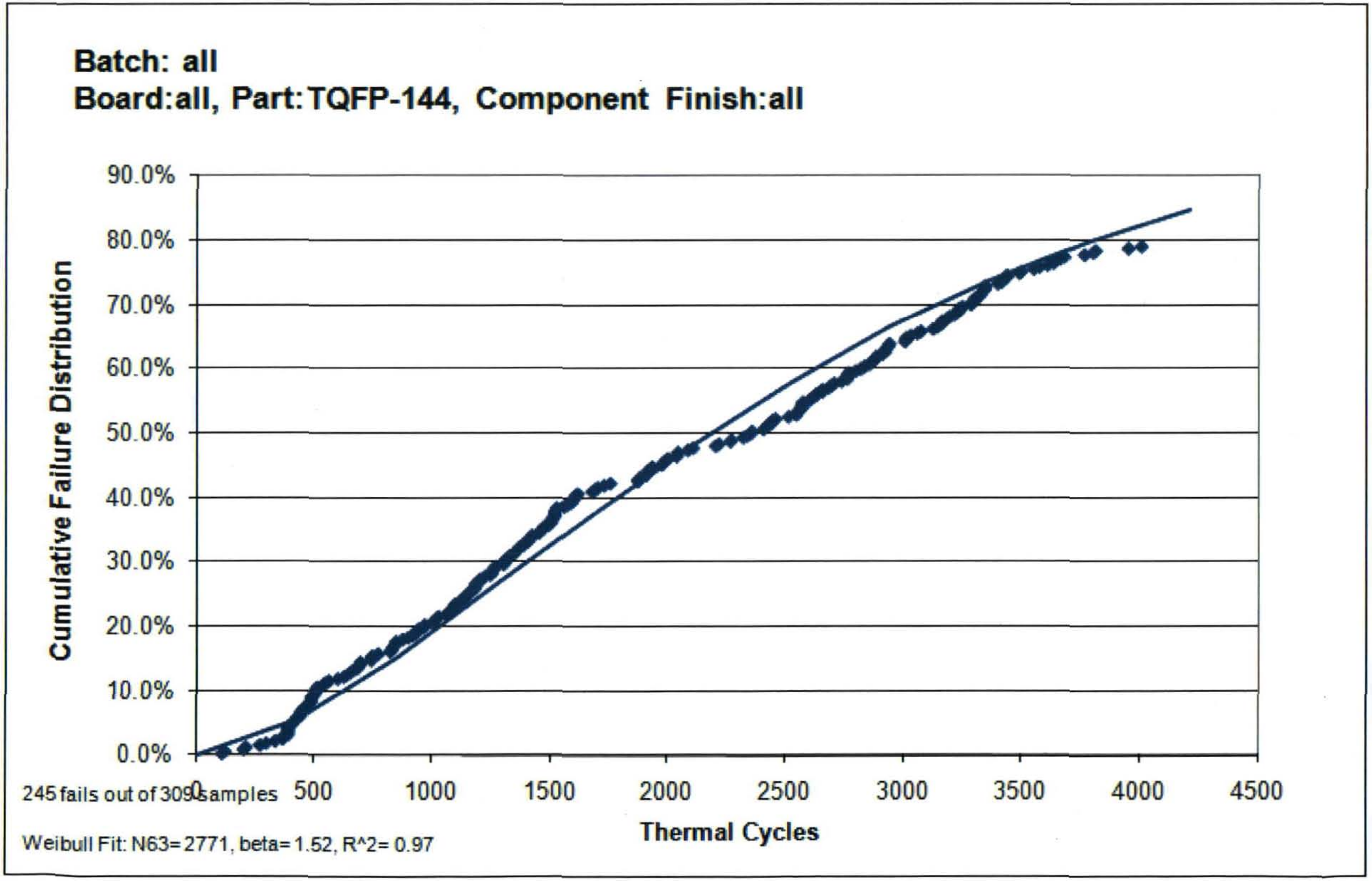


Thermal Cycle Testing (-55/+125°C)

Rockwell Collins

Data Snapshot from "Manufactured" Test Vehicles

- No "Rework" Data
- TQFP-144

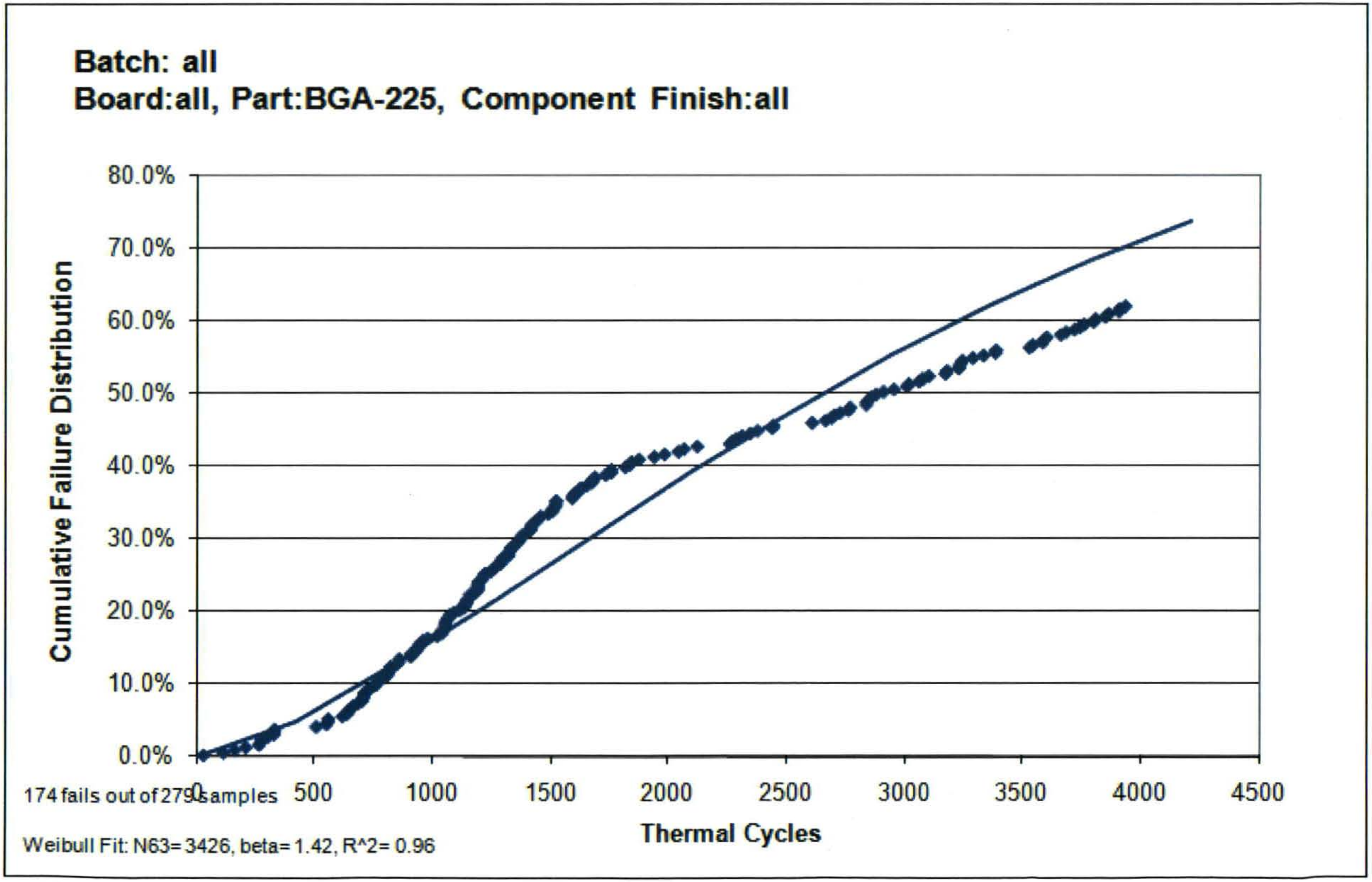


Thermal Cycle Testing (-55/+125°C)

Rockwell Collins

Data Snapshot from "Manufactured" Test Vehicles

- No "Rework" Data
- BGA-225

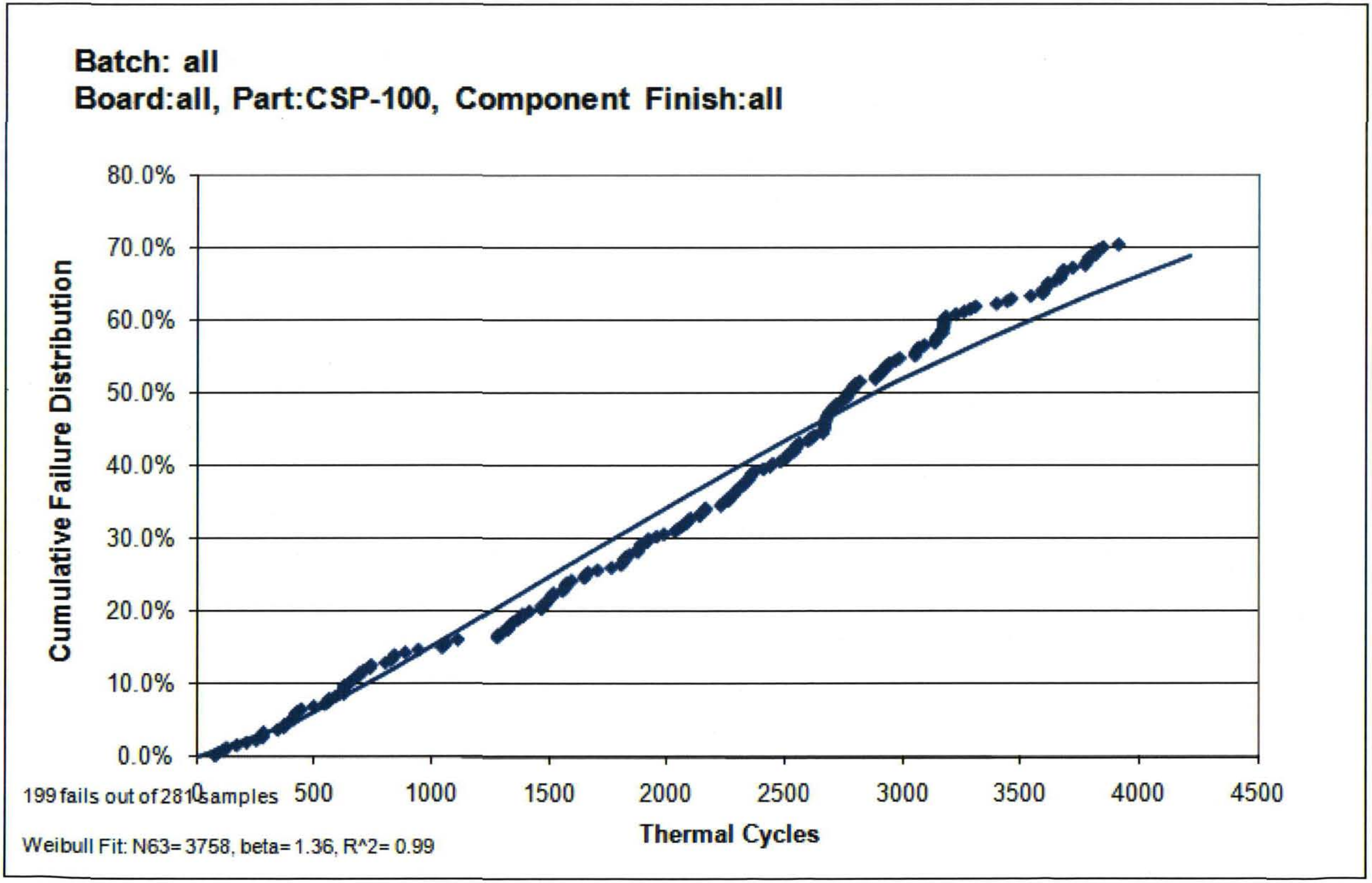


Thermal Cycle Testing ($-55/+125^oC$)

Rockwell Collins

Data Snapshot from "Manufactured" Test Vehicles

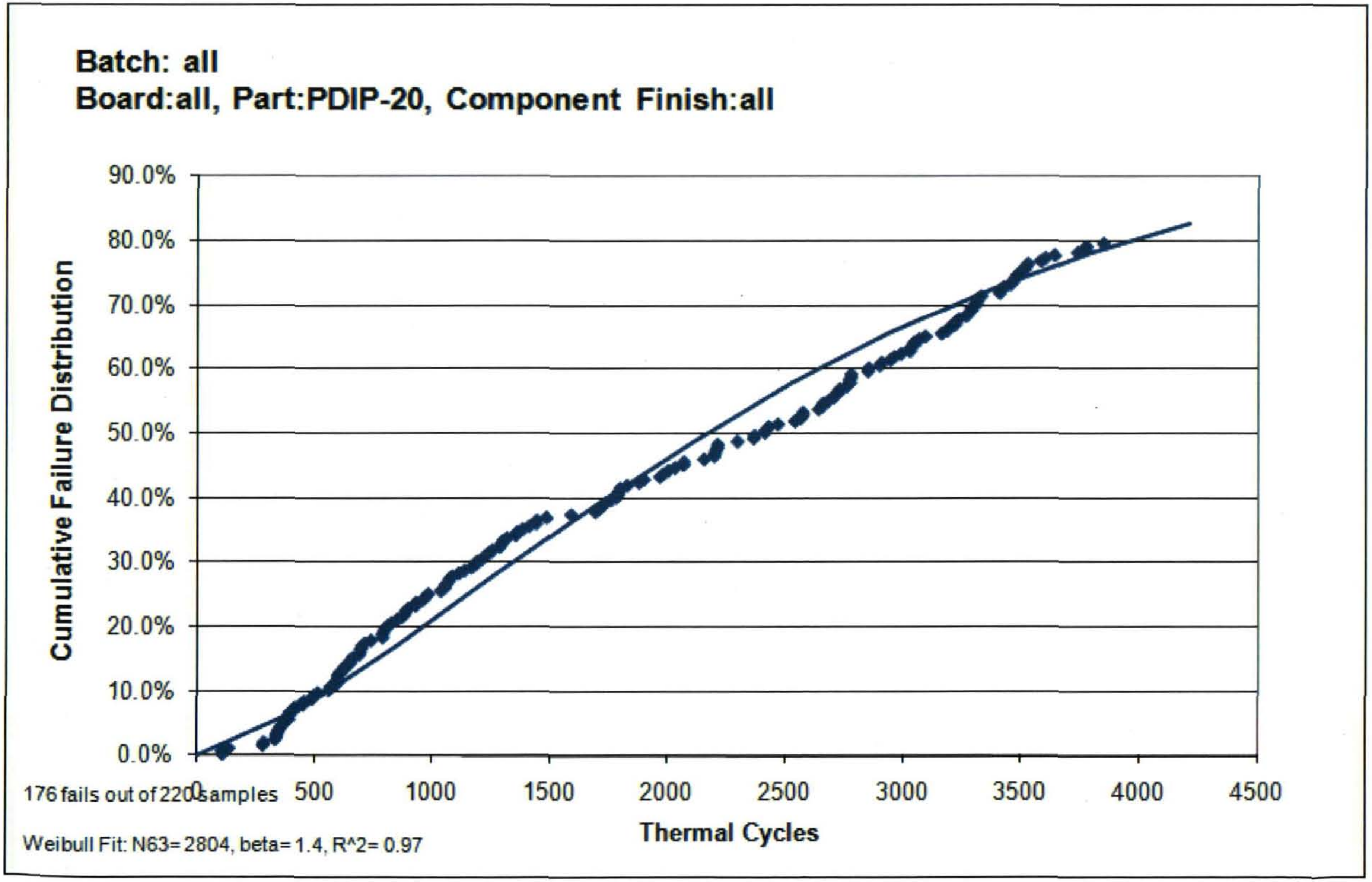
- No "Rework" Data
- CSP-100



Thermal Cycle Testing (-55/+125^oC)

Data Snapshot from "Manufactured" Test Vehicles

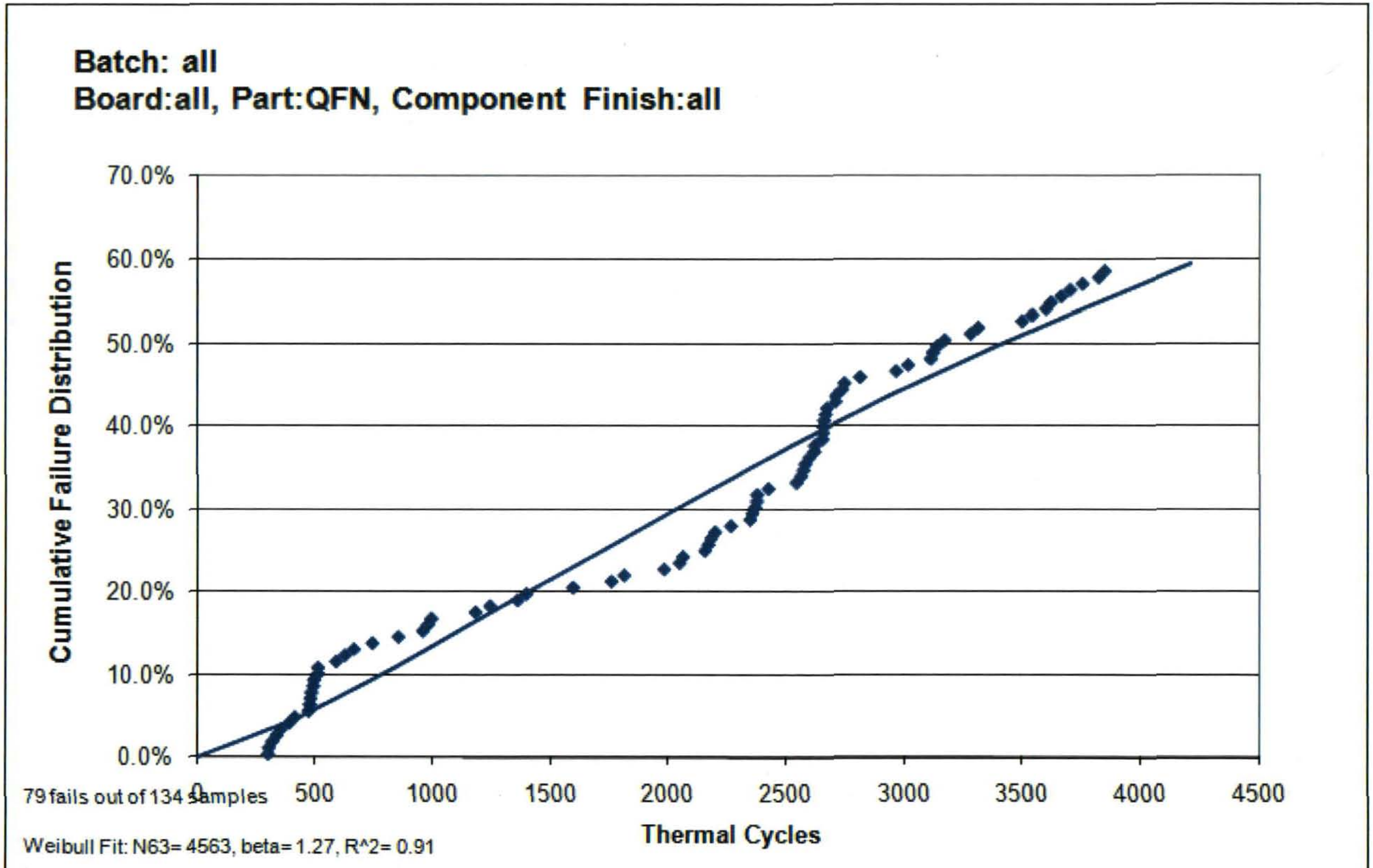
- No "Rework" Data
- PDIP-20



Thermal Cycle Testing (-55/+125°C)

Data Snapshot from “Manufactured” Test Vehicles

- No “Rework” Data
- QFN

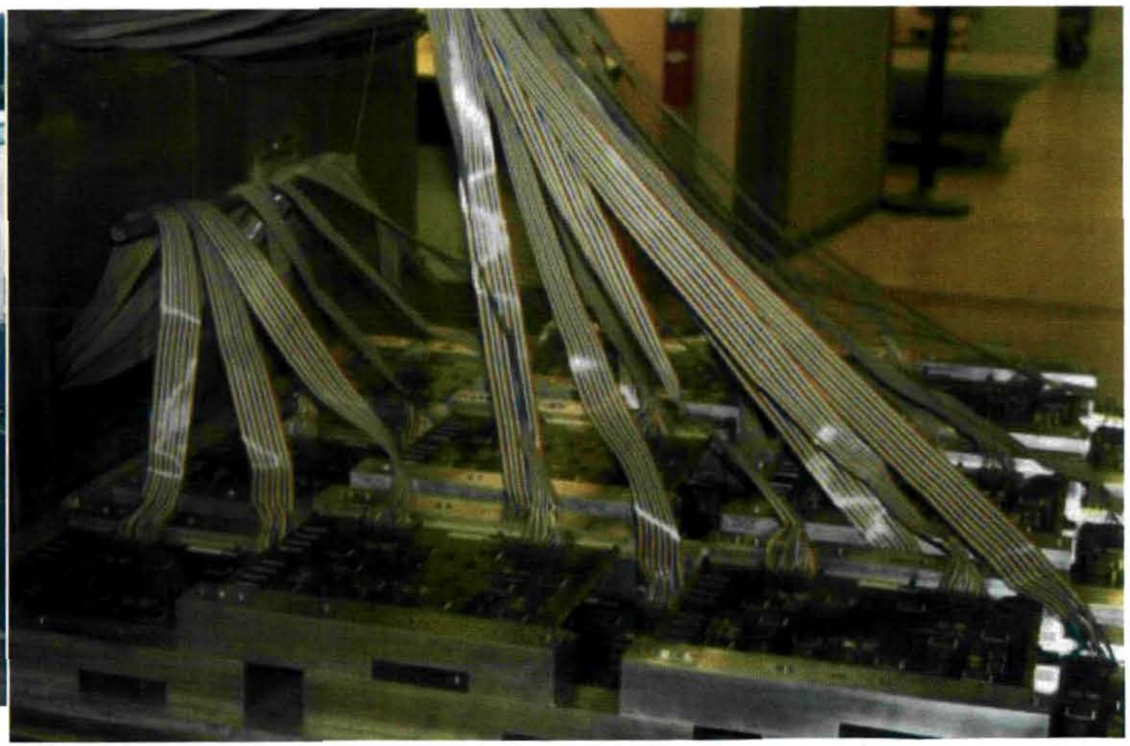


Combine Environments Testing

Raytheon

Thermal Cycle with Vibration

- -55°C to +125°C
- 20°C/minute ramp
- 15 minute dwell at -55°C and +125°C
- Vibration for the duration of the thermal cycle
- 10 g_{rms} pseudo-random vibration initially
- Increase vibration level 5 g_{rms} after every 50 cycles
- 55 g_{rms} maximum

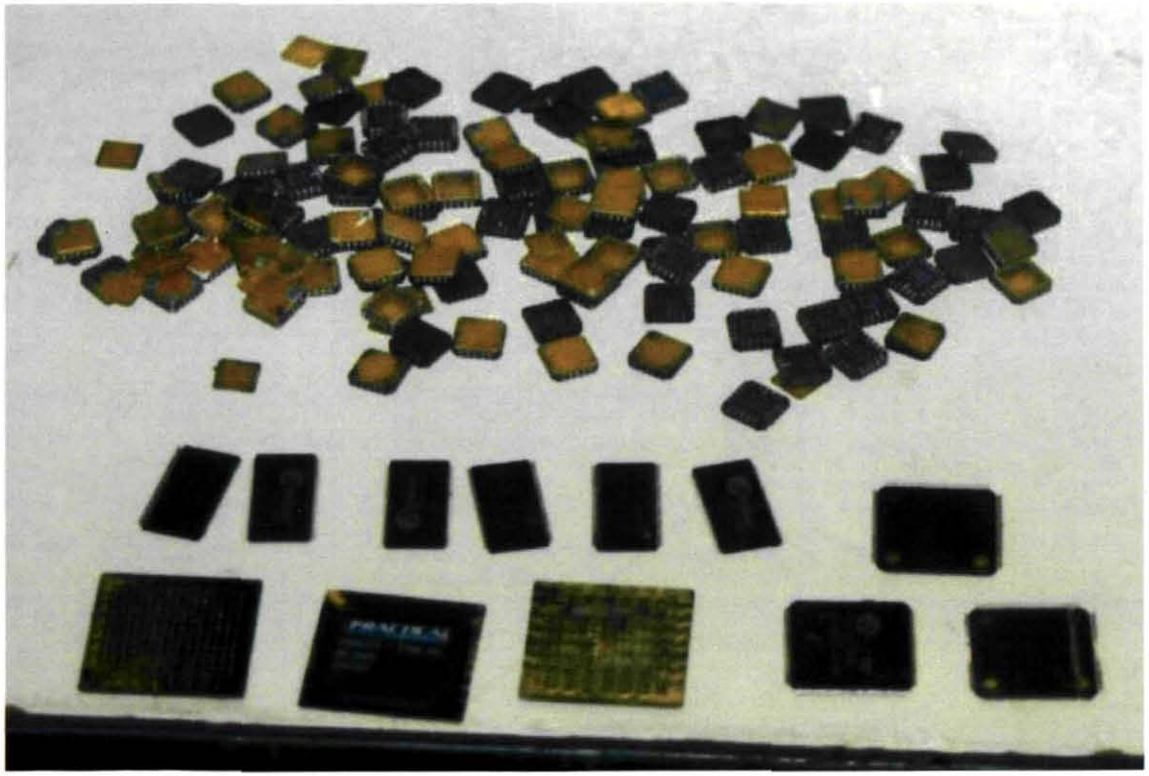


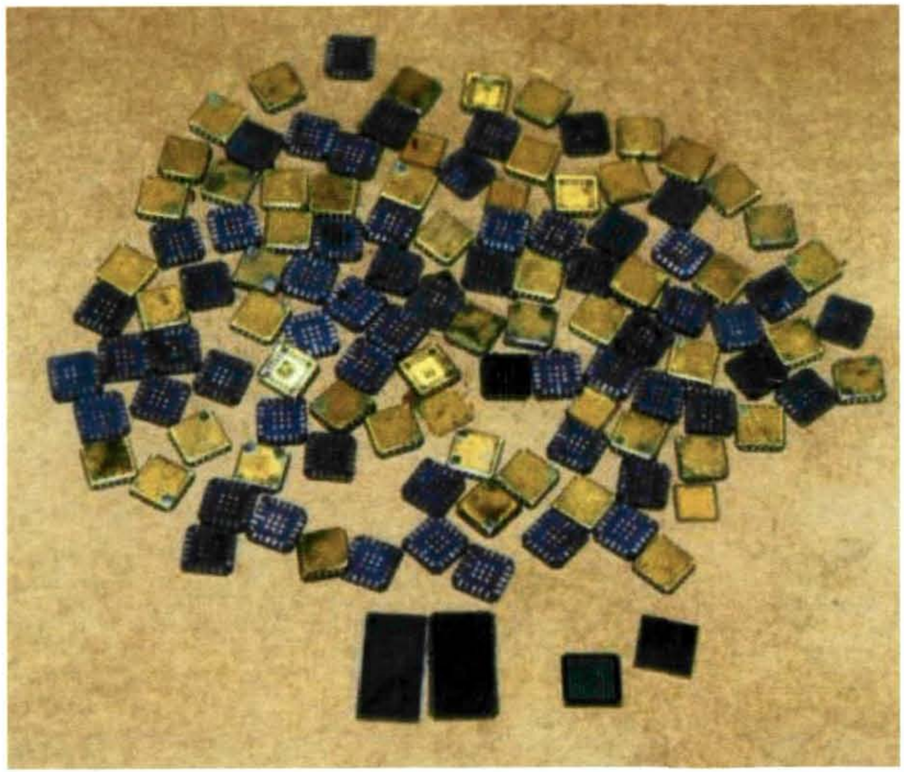
Combine Environments Testing

Raytheon

Overall, the component type had the greatest effect on solder joint reliability performance.

- The plated-through-hole components proved to be more reliable than the surface mount technology components.
- The plated-through-holes (PTH), PDIP-20, TQFP-144 and QFN-20 components per-formed the best.
- The BGA-225 components performed the worst.





Combine Environments Testing

Raytheon

Solder alloy had a secondary effect on solder joint reliability.

- In general, tin-lead finished components soldered with tin-lead solder paste were the most reliable with the exception of some components with lead contamination in the solder joints.
- In general, tin-silver-copper soldered components were less reliable than the tin-lead solder controls.
- <u>In several cases</u>, tin-silver-copper solder performed statistically as good as or equal to the baseline, eutectic tin-lead solder.

In general, reworked components were less reliable than the unreworked components. This is especially true with reworked lead-free CSP-100, reworked lead-free BGA-225

Combine Environments Testing

Raytheon

From this testing, it appears the selection of component type and lead-free solder combinations should be considered critical factors when considering converting to lead-free solder assembly, especially for surface mount technology design configurations.

Manufactured Test Vehicles

Board Finish	Component	Finish	Solder	Number of Failed Components
Im. Ag	BGA-225	SAC405	SAC305	76% (19 of 25)
			SN100C	76% (19 of 25)
			SnPb	92% (23 of 25)
		SnPb	SAC305	84% (21 of 25)
			SN100C	88% (22 of 25)
			SnPb	60% (15 of 25)
Im. Ag	CLCC-20	SAC305	SAC305	96% (24 of 25)
			SN100C	96% (24 of 25)
			SnPb	92% (23 of 25)
		SnPb	SAC305	100% (25 of 25)
			SN100C	88% (22 of 25)
			SnPb	84% (21 of 25)
Im. Ag	QFN-20	Matte Sn	SAC305	20% (5 of 25)
			SN100C	40% (10 of 25)
			SnPb	20% (5 of 25)
Im. Ag	TQFP-144	Matte Sn	SAC305	24% (6 of 25)
			SN100C	52% (13 of 25)
			SnPb	32% (8 of 25)
		SnPb Dip	SAC305	0% (0 of 25)
			SN100C	60% (15 of 25)
			SnPb	8% (2 of 25)

Combine Environments Testing

Raytheon

Rework Test Vehicles

Board Finish	Component	Finish	Solder	New Component Finish	Rework Solder	Number of Failed Components
Im. Ag	BGA-225	SAC405	SAC305	SAC405	Flux Only	60% (9 of 15)
					SnPb	33% (5 of 15)
			SnPb			50% (10 of 20)
		SnPb	SAC305			65% (13 of 20)
			SnPb	SAC405	SnPb	80% (12 of 15)
				SnPb	Flux Only	20% (3 of 15)
Im. Ag	PDIP-20	NiPdAu	SnPb			7% (1 of 15)
		Sn	SN100C	Sn	SN100C	20% (2 of 10)
						7% (2 of 30)
			SnPb			13% (2 of 15)
		SnPb	SnPb	Sn	SnPb	40% (4 of 10)
Im. Ag	TSOP-50	Sn	SAC305	Sn	SnPb	60% (6 of 10)
			SnPb			20% (3 of 15)
		SnBi	SAC305	SnBi	SAC305	90% (9 of 10)
						67% (10 of 15)
			SnPb			33% (5 of 15)
		SnPb	SAC305			33% (5 of 15)
			SnPb	Sn	SnPb	50% (5 of 10)
				SnPb	SnPb	60% (6 of 10)

Combine Environments Testing

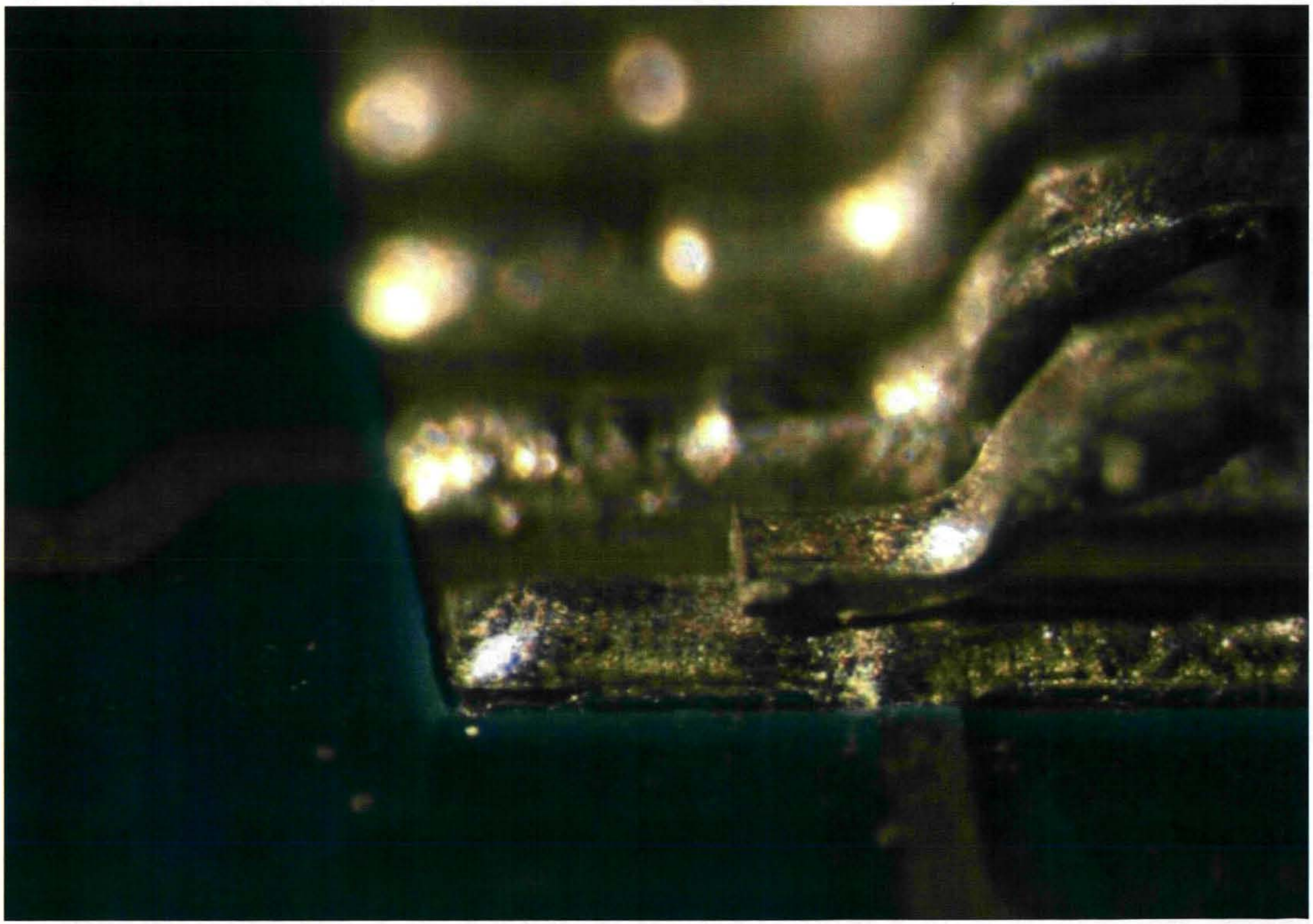
Raytheon

Failure Analysis In-Progress

Failure Analysis Location	Test Vehicle	Component Location	Selection Criteria
COM DEV	21	U34	Mfg group - No signal, failed at 0 cycles
	21	U57	Mfg group - Failed at cycle 1
	119	U36	Mfg group - Surrounded by components that fell off; failed at 233 cycles
	119	U39	Mfg group - Surrounded by components that fell off; failed at 318 cycles
	142	U13	Rwk group - Adjacent to rwked components, survived all 650 cycles
	181	U56	Rwk group - Rwked component failed at cycle 1
	181	U25	Rwk group - Rwked component failed at cycle 1
Lockheed Martin	117	U4	Mfg group - Failed at 20 cycles; SN100C solder paste used
	140	U11	Rwk group - Damaged pad from rwk - Failed at 398 cycles
	183	U41	Rwk group - Failed at cycle 1, was not rwked
Nihon Superior	23	U30	Mfg group - Survived 650 cycles, surrounded by components that fell off
	23	U43	Mfg group - Failed at 120 cycles, located near center of TV
	72	U29	Mfg group - Location in chamber (low fails); failed at 161 cycles
	158	U6	Rwk group - Rwked component failed at cycle 1
	180	U21	Rwk group - Rwked component failed at cycle 1

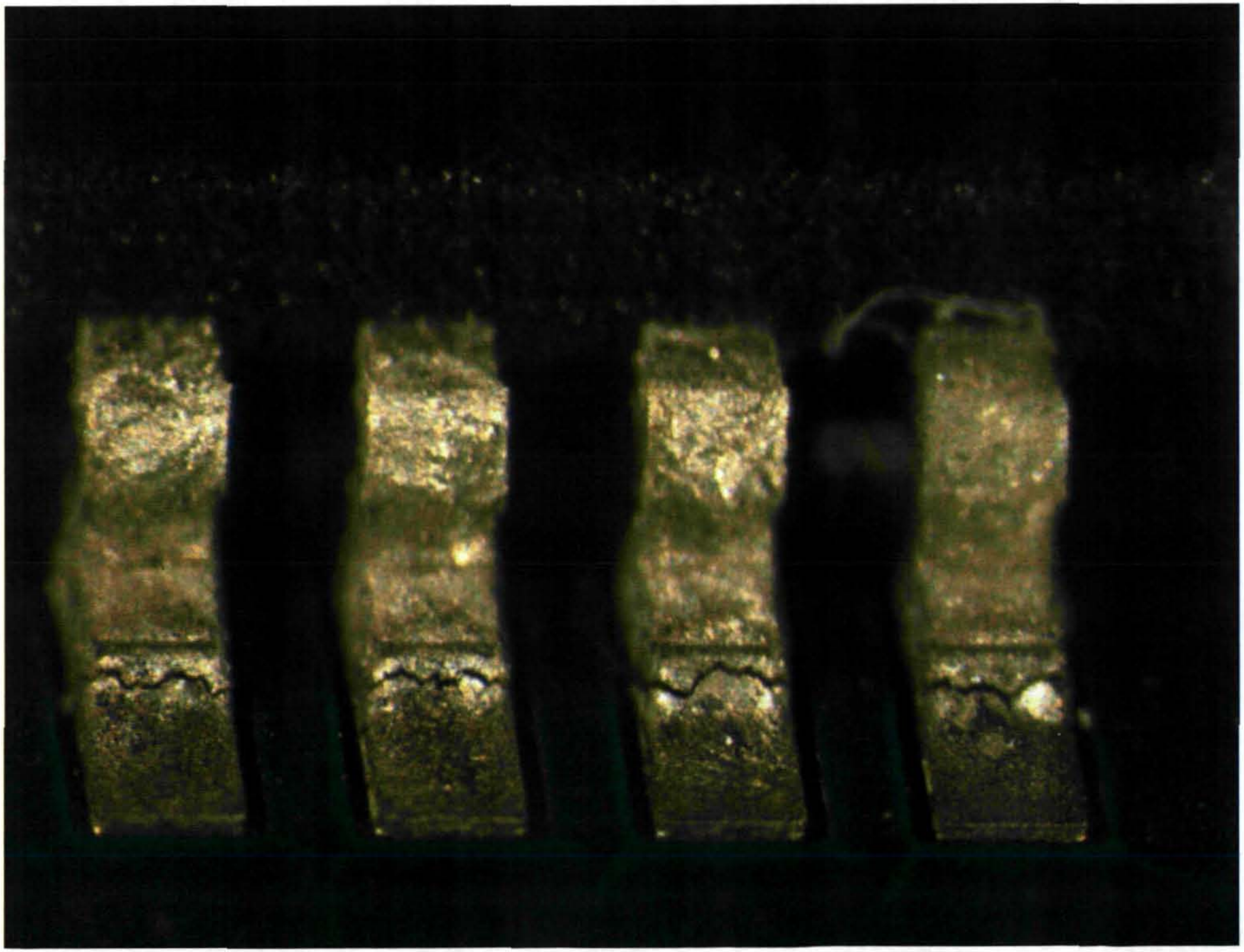
Combined Environments Failure Analysis

Test Vehicle 21; Component U34 – TQFP 144; Board Finish – Imm. Ag
SnPb Manufactured (Batch C) - Solder (SnPb) - Component Finish (SnPb Dip): No signal, failed at 0 cycles



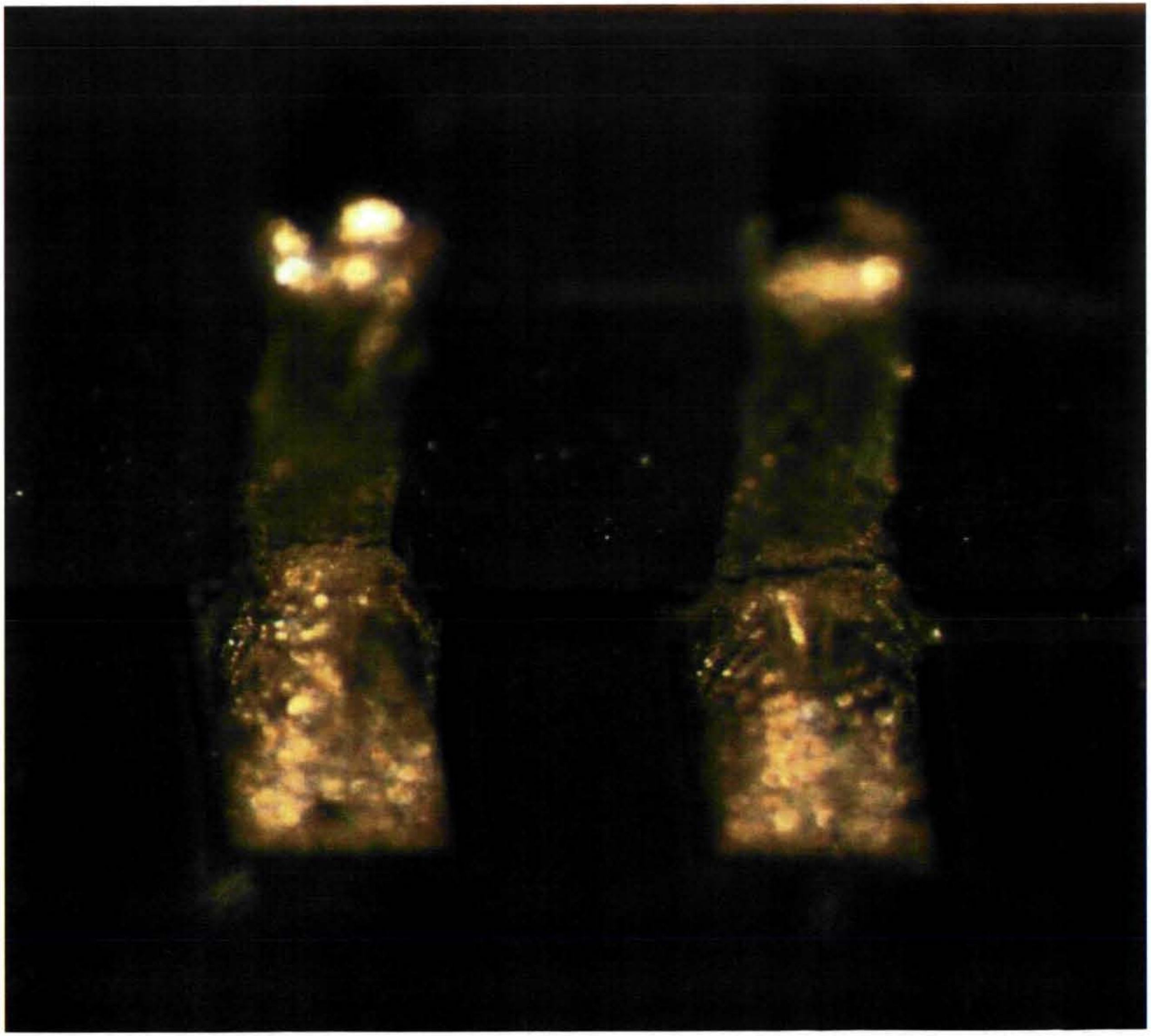
Combined Environments Failure Analysis

Test Vehicle 119; Component U39 – TSOP 50; Board Finish – Imm. Ag
Lead-Free Manufactured (Batch G) - Solder (SN100C) - Component Finish (SnPb)
Surrounded by components that fell off; failed at 318 cycles



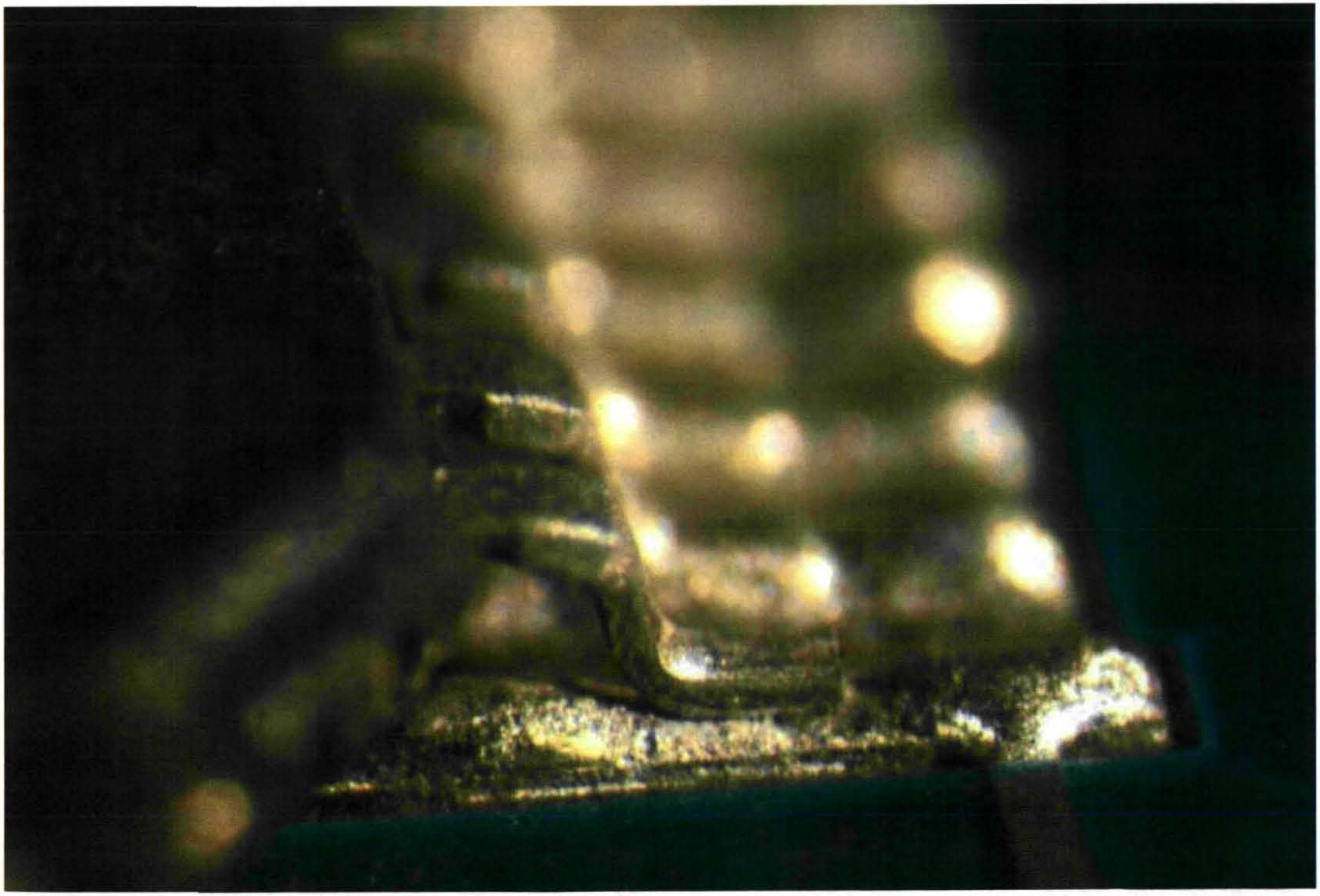
Combined Environments Failure Analysis

Test Vehicle 142; Component U13 – CLCC; Board Finish – Imm. Ag
SnPb Rework (Batch B) - Solder (SnPb) - Component Finish (SAC305)
Adjacent to reworked components, survived all 650 cycles



Combined Environments Failure Analysis

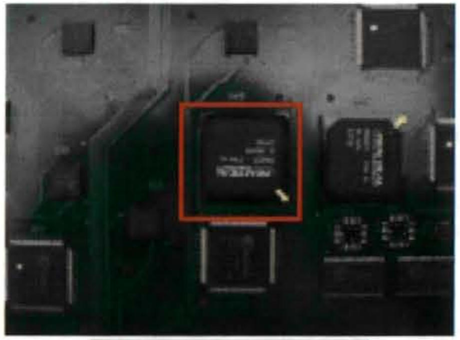
Test Vehicle 21; Component U57 – TQFP 144; Board Finish – Imm. Ag
SnPb Manufactured (Batch C) - Solder (SnPb) - Component Finish (SnPb Dip)
Failed at cycle 1



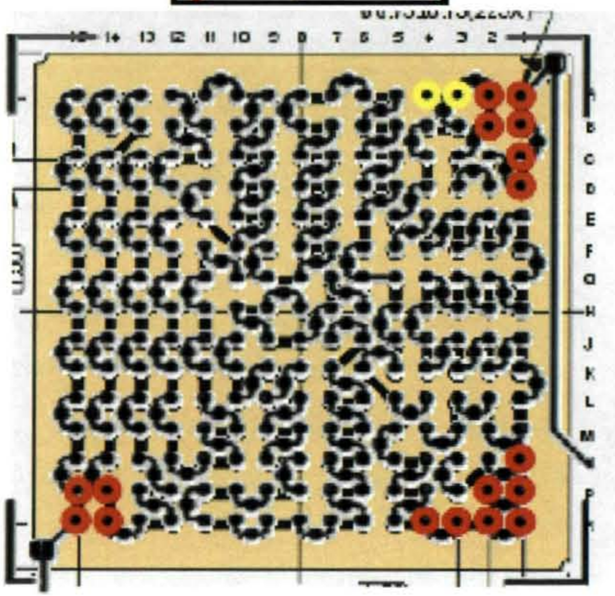
Combined Environments Failure Analysis

Test Vehicle 23

SnPb Manufactured
Ag-SnPb-SnPb

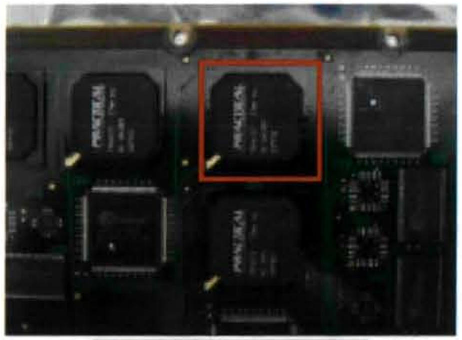


② U43(BGA225)

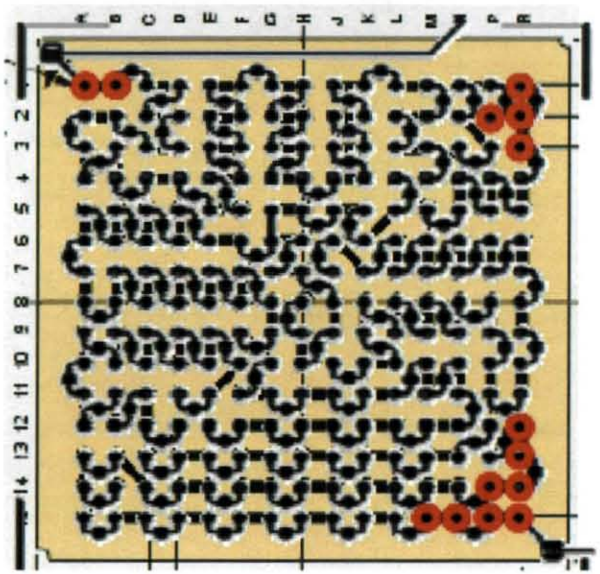


Test Vehicle 158

SnPb REWORK
ENIG-SnPb-SnPb

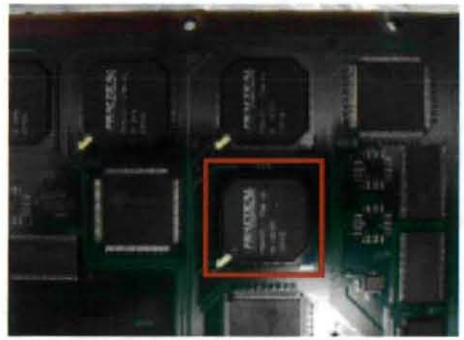


④ U6(BGA225)

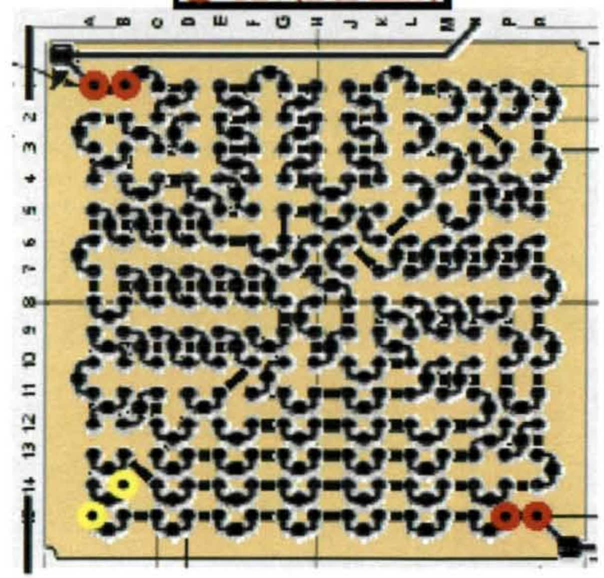


Test Vehicle 180

Pb-Free REWORK
Ag-SAC305-SnCu



⑤ U21(BGA225)

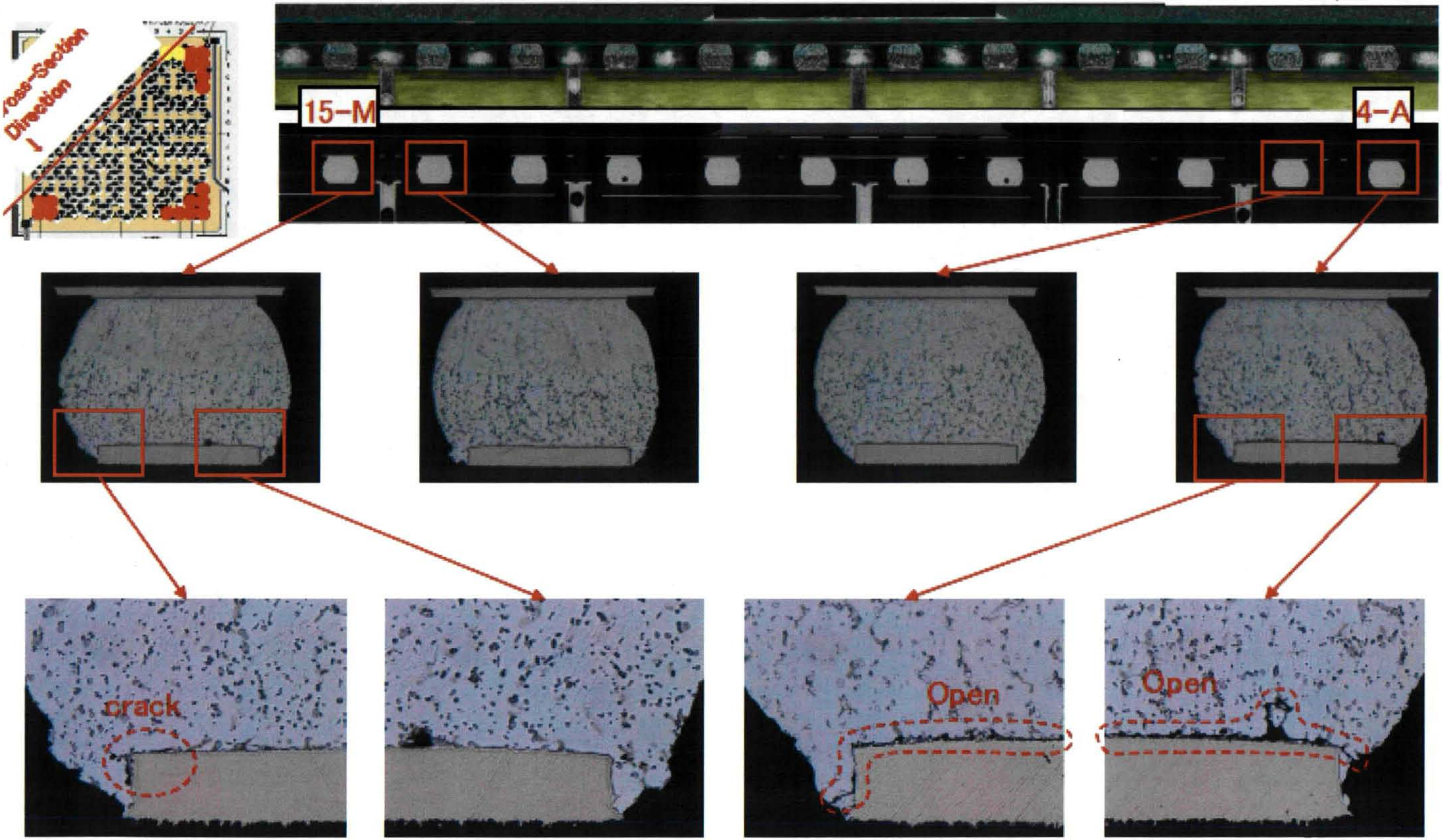


:Open

:High resistance

Combined Environments Failure Analysis

SAC405 solder balls / SnPb solder paste / SnPb reflow profile



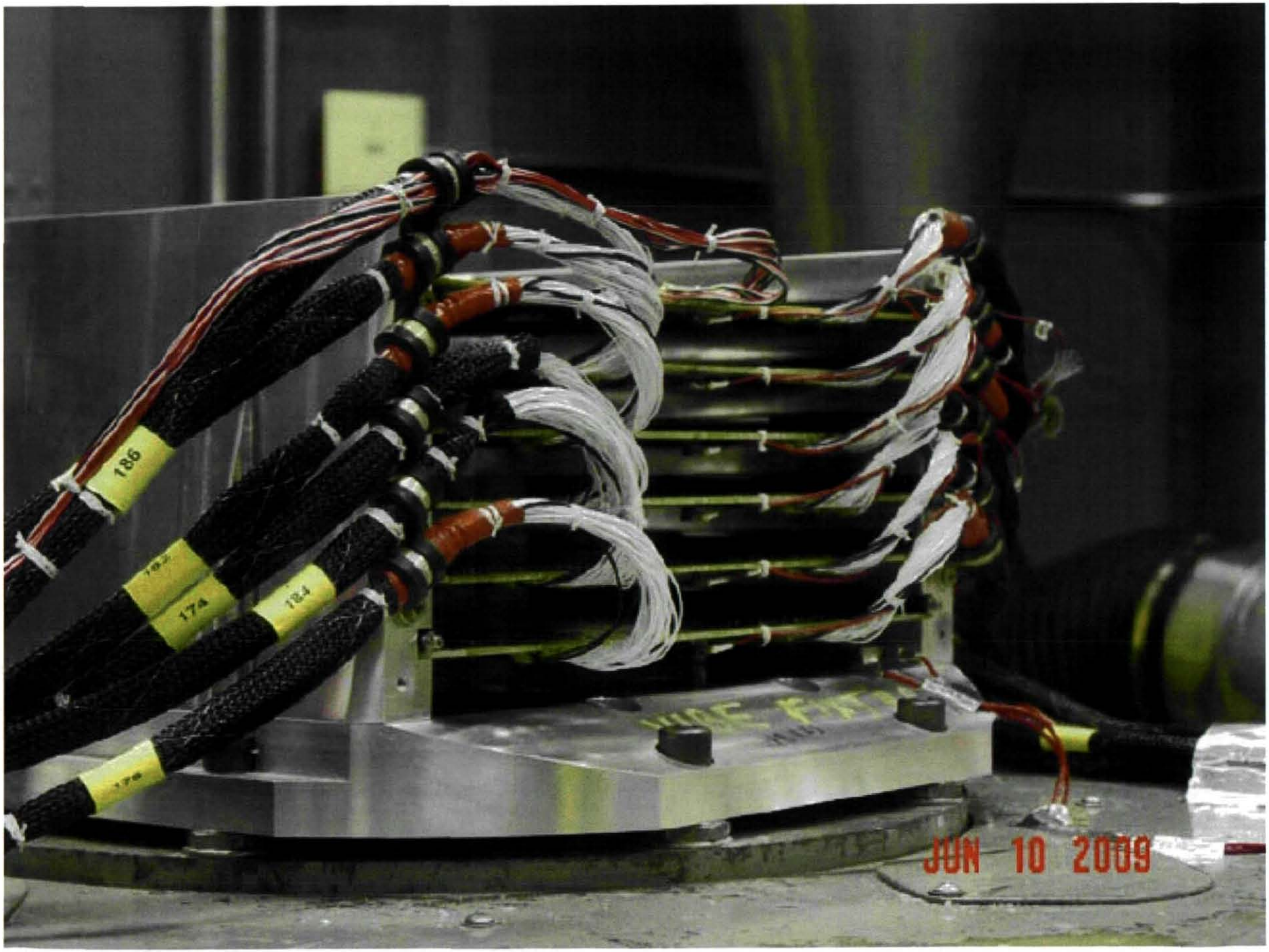
Mechanical Shock Testing

Project representatives felt that only testing in the Z-axis was required as this is the only axis which allows significant board bending and subsequent solder joint failures.

Parameters	The shock transients will be applied perpendicular to the plane of the board and will be increased after every 100 shocks (i.e., a step stress test). For Level 6 (300 G's), 400 shocks will be applied. Frequency range is 40 to 1000 Hz. SRS damping: 5%			
	Test Shock Response Spectra	Amplitude (G's)	Te (msec)	Shocks per Level
	Modified Functional Test for Flight Equipment (Level 1)	20	<30	100
	Modified Functional Test for Ground Equipment (Level 2)	40	<30	100
	Modified Crash Hazard Test for Ground Equipment (Level 3)	75	<30	100
	Level 4	100	<30	100
	Level 5	200	<30	100
	Level 6	300	<30	400

Number of Test Vehicles Required				
Manufactured		Rework		
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5
Trials per Specimen		1		

Mechanical Shock Testing



Mechanical Shock Testing

- The very first components to fail were lead-free PDIP components
  - Lead cracking in the fillet area is being observed as well as some trace cracking near the corner leads. It is not possible to determine if one event happened before the other or if the events are happening simultaneously.
- All of the test vehicles passed the first 3 levels of testing which were conducted per MIL-STD-810F, Method 516.5; Modified Functional Test for Flight Equipment (Level 1), Modified Functional Test for Ground Equipment (Level 2), and Modified Crash Hazard Test for Ground Equipment (Level 3).
  - 100 shocks were conducted in the z-axis for each of the three levels, equating to conducting each of the three tests 33 times.
- It appears that the predominant failure mechanism for the BGA components was pad cratering no matter the solder alloy; lead-free or SnPb.

Mechanical Shock Testing

In general SAC305 performed as well as the SnPb for surface mount components.

	% of Components Failed During Mechanical Shock Testing			
	"Manufactured" Test Vehicles		"Rework" Test Vehicles	
	SnPb	Pb-Free	SnPb	Pb-Free
Component				
BGA-225	94	96	95	100
CLCC-20	22	30	22	30
CSP-100	32	26	42	38
PDIP-20	53	73	54	58
QFN-20	0	10	0	0
TQFP-144	70	62	68	80
TSOP-50	4	0	22	20

Mechanical Shock Testing

BOEING

	Relative Ranking (Solder Alloy / Component Finish)									
BGA-225	Sn37Pb/ Sn37Pb	SAC305/ SAC405	Sn37Pb/ SAC405	SAC305/ Sn37Pb	Rwk Flux Only/ Sn37Pb	Rwk Flux Only/ SAC405	Rwk Sn37Pb/SAC405 (SnPb Profile)	Rwk Sn37Pb/SAC405 (Pb-Free Profile)		
	1	1	2	1	1	1	2	1		
CLCC-20	Sn37Pb/ Sn37Pb	SAC305/ SAC305	Sn37Pb/ SAC305	SAC305/ Sn37Pb						
	1	2	2	2						
CSP-100	Sn37Pb/ Sn37Pb	SAC305/ SAC105	Sn37Pb/ SAC105	SAC305/ Sn37Pb	Rwk Flux Only/ Sn37Pb	Rwk Flux Only/ SAC105	Rwk Sn37Pb/SAC105 (SnPb Profile)	Rwk Sn37Pb/SAC105 (Pb-Free Profile)		
	1	1	2	1	2	1	2	2		
PDIP-20	Sn37Pb/ SnPb	SN100C/ Sn	Sn37Pb/ NiPdAu	Rwk Sn37Pb/ Sn	Rwk Sn100C/ Sn					
	1	1	1	2	2					
QFN-20	Sn37Pb/ Sn37Pb	SAC305/ Sn	Sn37Pb/ Sn	SAC305/ Sn37Pb						
	X	X	X	X						
TQFP-144	Sn37Pb/ Sn	SAC305/ Sn	Sn37Pb/ NiPdAu	SAC305/ NiPdAu	Sn37Pb/ Sn37Pb Dip	SAC305/ SAC305 Dip				
	1	1	1	1	1	2				
TSOP-50	Sn37Pb/ SnPb	Sn37Pb/ Sn	Sn37Pb/ SnBi	SAC305/ Sn	SAC305/ SnBi	SAC305/ SnPb	Rwk Sn37Pb/ SnPb	Rwk Sn37Pb/Sn (SnPb Profile)	Rwk Sn37Pb/Sn (Pb-free Profile)	Rwk SAC305/ SnBi
	X	X	X	X	X	X	2	2	2	2

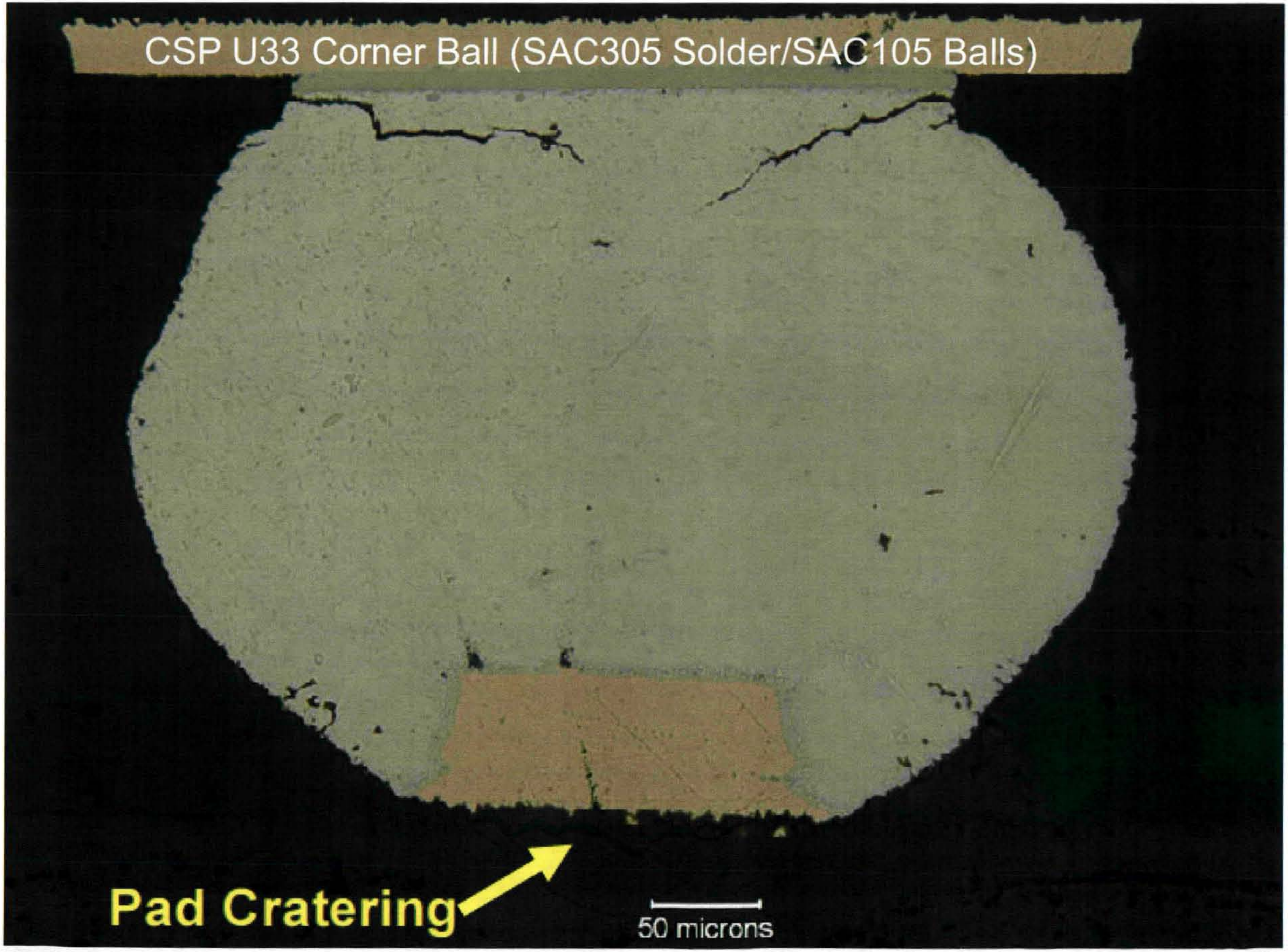
X = Not enough failures to rank

1 = as good as or better than Sn37Pb control

2 = worse than Sn37Pb control

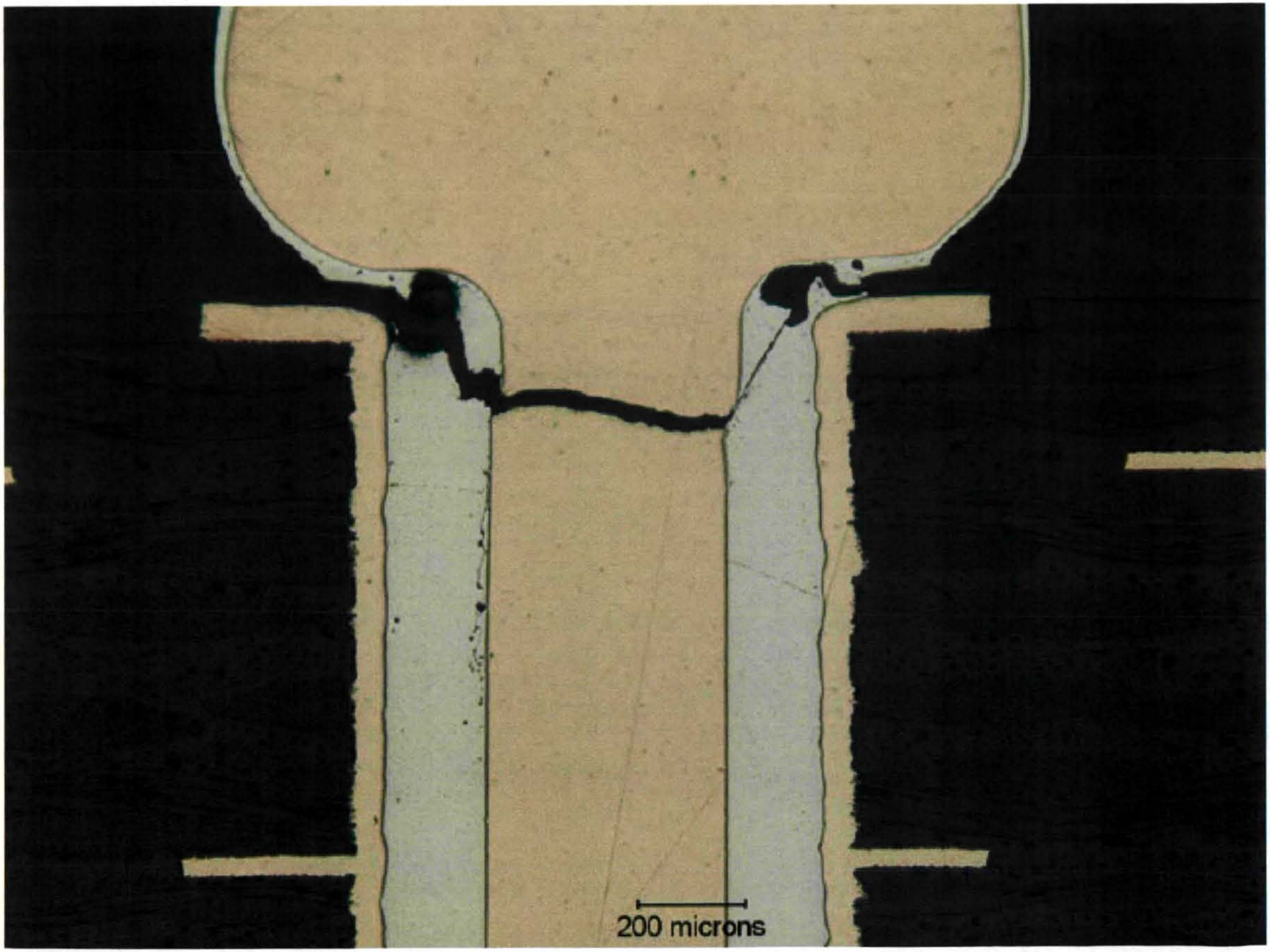
3 = much worse than Sn37Pb control

Mechanical Shock Testing



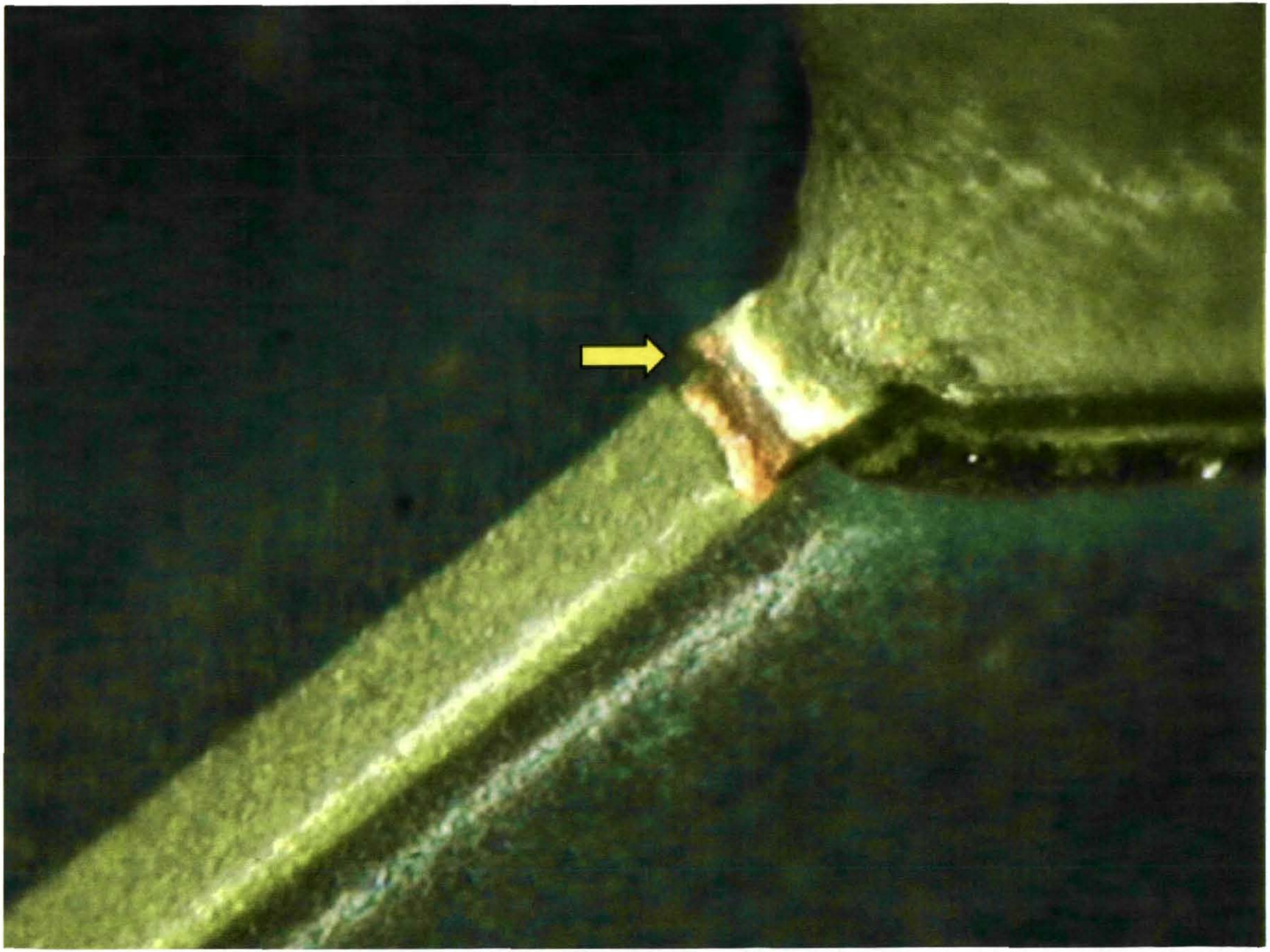
Mechanical Shock Testing

PDIP U8 Corner Lead (SN100C Solder/Sn Finish)

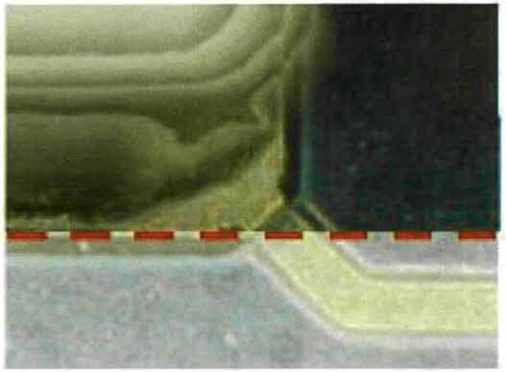


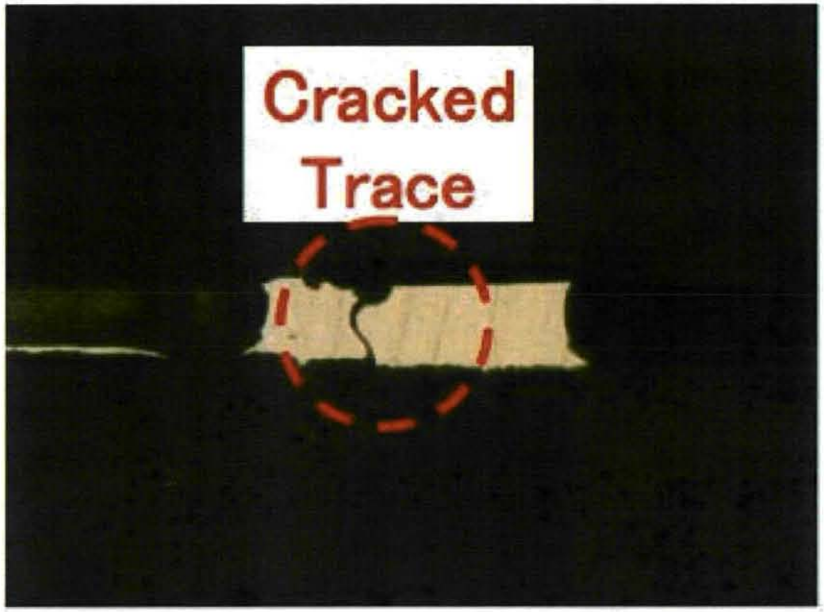
Mechanical Shock Testing

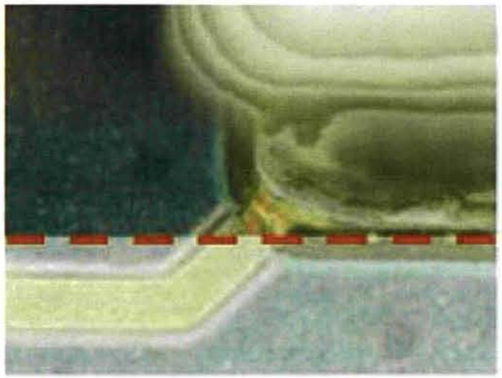
PDIP U38 Trace Crack (SN100C)

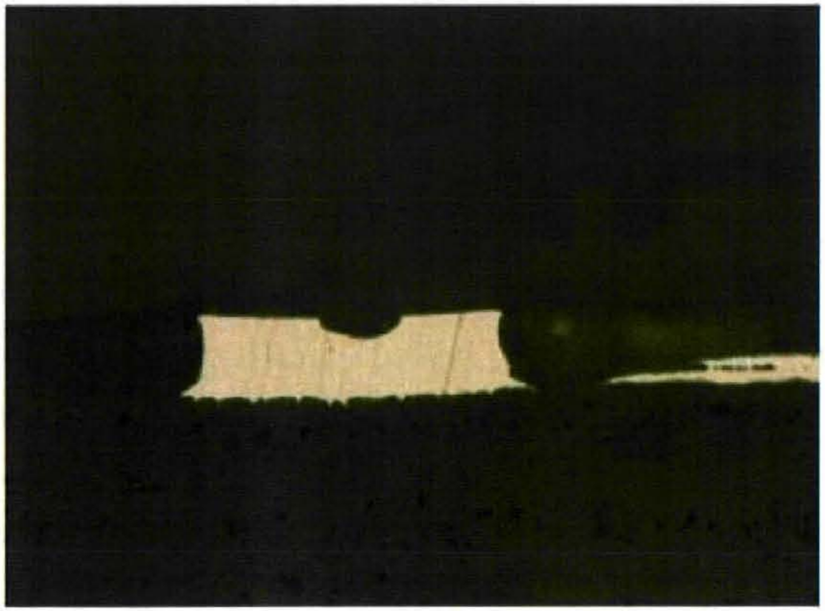


Mechanical Shock Testing









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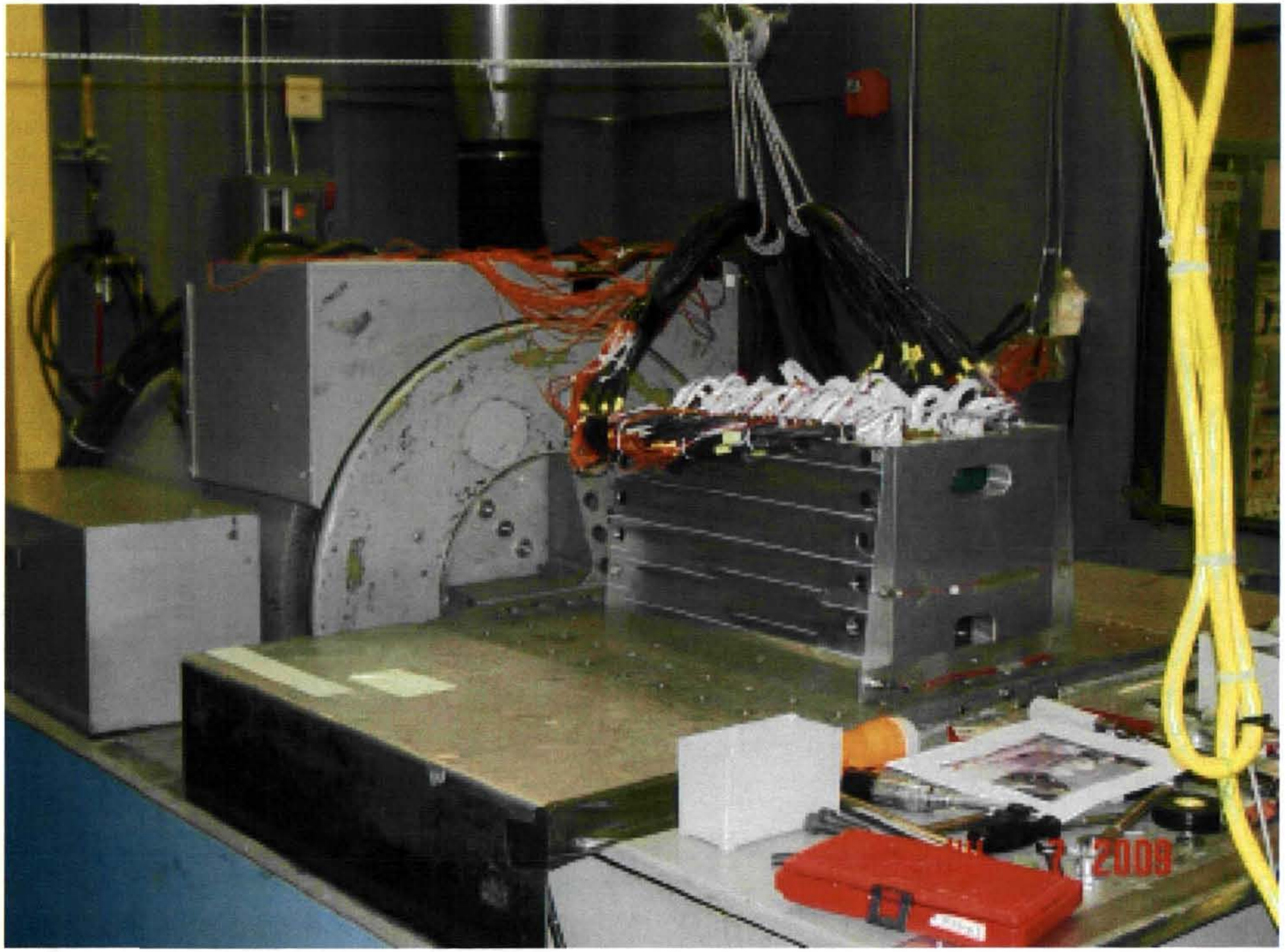
Vibration Testing

Subject the test vehicles to 8.0 g_{rms} for one hour. Then increase the <u>Z-axis</u> vibration level in 2.0 g_{rms} increments, shaking for one hour per step until the 20.0 g_{rms} level is completed. Then subject the test vehicles to a final one hour of vibration at 28.0 g_{rms}.



Vibration Testing

- Very early PDIP failures were observed.
- At an initial glance, the data does not look much different than the JCAA/JGPP test results.
- There does seem to be a big difference between solder alloys.

Vibration Testing

(Includes Mixed Solders)	% of Components Failed During Vibration Testing				
	"Manufactured" Test Vehicles			"Rework" Test Vehicles	
	SnPb Paste	SAC305 Paste	SN100C Paste	SnPb Paste	Pb-Free Paste
Component					
BGA-225	84	98	100	100	100
CLCC-20	32	43	90	35	68
CSP-100	62	73	70	62	80
PDIP-20	98	92	100	88	96
QFN-20	0	21	20	8	10
TQFP-144	60	63	64	70	70
TSOP-50	62	73	86	77	80

Vibration Testing

BOEING

Relative Ranking (Solder Alloy / Component Finish)

3GA-225	Sn37Pb/ Sn37Pb	SAC305/ SAC405	Sn37Pb/ SAC405	SAC305/ Sn37Pb	Rwk Flux Only/ Sn37Pb	Rwk Flux Only/ SAC405	Rwk Sn37Pb/SAC405 (SnPb Profile)	Rwk Sn37Pb/SAC405 (Pb-Free Profile)	SN100C/ SAC405
	1	3	3	3	3	3	3	3	3

CLCC-20	Sn37Pb/ Sn37Pb	SAC305/ SAC305	Sn37Pb/ SAC305	SAC305/ Sn37Pb	SN100C/ SAC305
	1	3	2	3	3

CSP-100	Sn37Pb/ Sn37Pb	SAC305/ SAC105	Sn37Pb/ SAC105	SAC305/ Sn37Pb	Rwk Flux Only/ Sn37Pb	Rwk Flux Only/ SAC105	Rwk Sn37Pb/SAC105 (SnPb Profile)	Rwk Sn37Pb/SAC105 (Pb-Free Profile)	SN100C/ SAC105
	1	1	1	2	1	2	1	3	1

PDIP-20	Sn37Pb/ SnPb	SN100C/ Sn	Sn37Pb/ NiPdAu	Rwk Sn37Pb/ Sn	Rwk Sn100C/ Sn	SN100C/ NiPdAu
	1	3	2	3	3	3

QFN-20	Sn37Pb/ Sn37Pb	SAC305/ Sn	Sn37Pb/ Sn	SAC305/ Sn37Pb	SN100C/ Sn
	1	2	1	1	2

QFP-144	Sn37Pb/ Sn	SAC305/ Sn	Sn37Pb/ NiPdAu	SAC305/ NiPdAu	Sn37Pb/ Sn37Pb Dip	SAC305/ SAC305 Dip	SN100C/ Sn
	1	1	1	2	1	2	1

TSOP-50	Sn37Pb/ SnPb	Sn37Pb/ Sn	Sn37Pb/ SnBi	SAC305/ Sn	SAC305/ SnBi	SAC305/ SnPb	Rwk Sn37Pb/ SnPb	Rwk Sn37Pb/Sn (SnPb Profile)	Rwk Sn37Pb/Sn (Pb-free Profile)	Rwk SAC305/ SnBi	SN100C/ Sn	SN100 SnBi
	1	2*	2*	2*	2*	2	2	2*	2*	2	2	2

*Performance relative to Sn37Pb control may depend on orientation of the TSOP

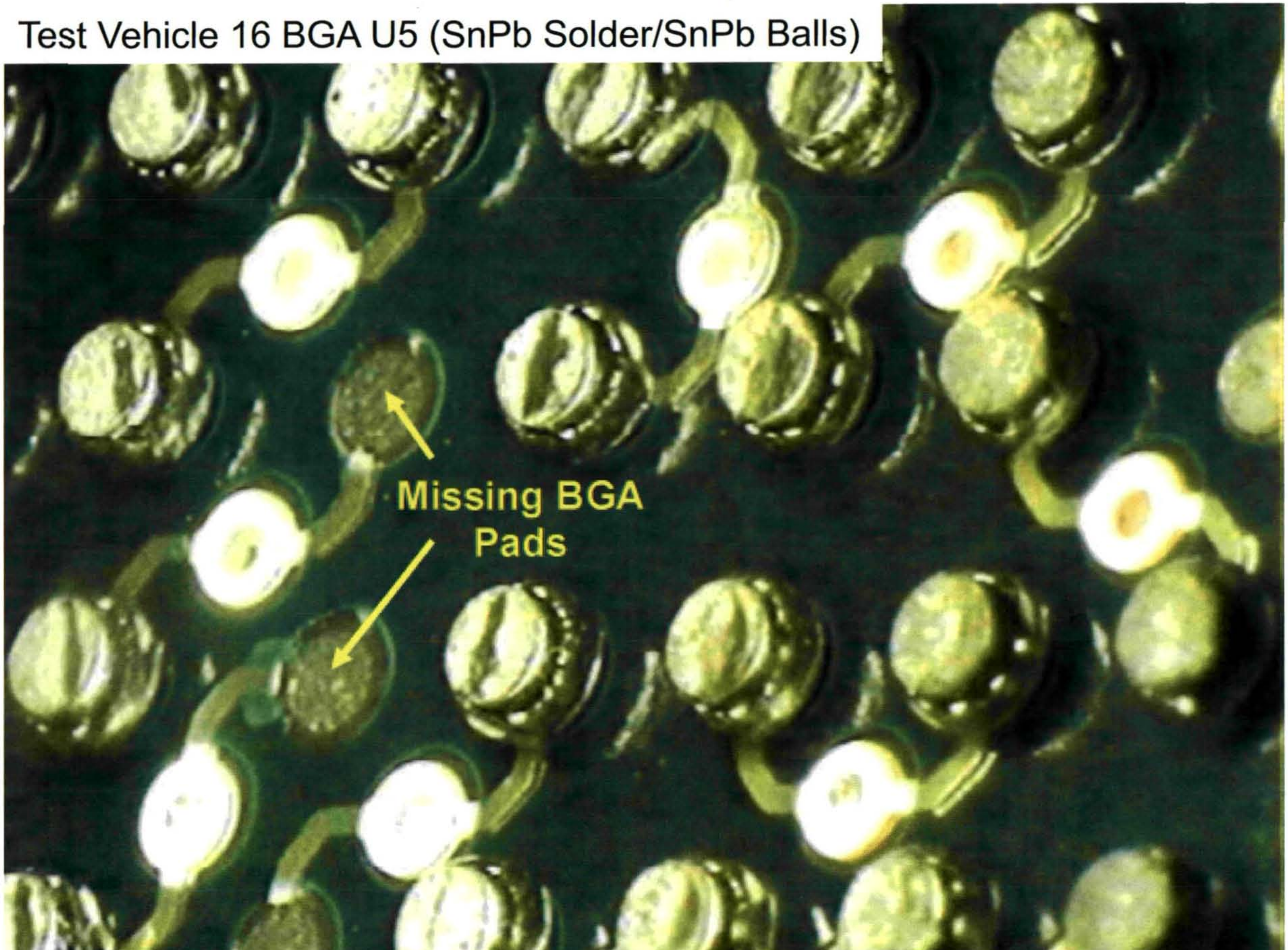
: as good as or better than Sn37Pb control

: worse than Sn37Pb control

: much worse than Sn37Pb control

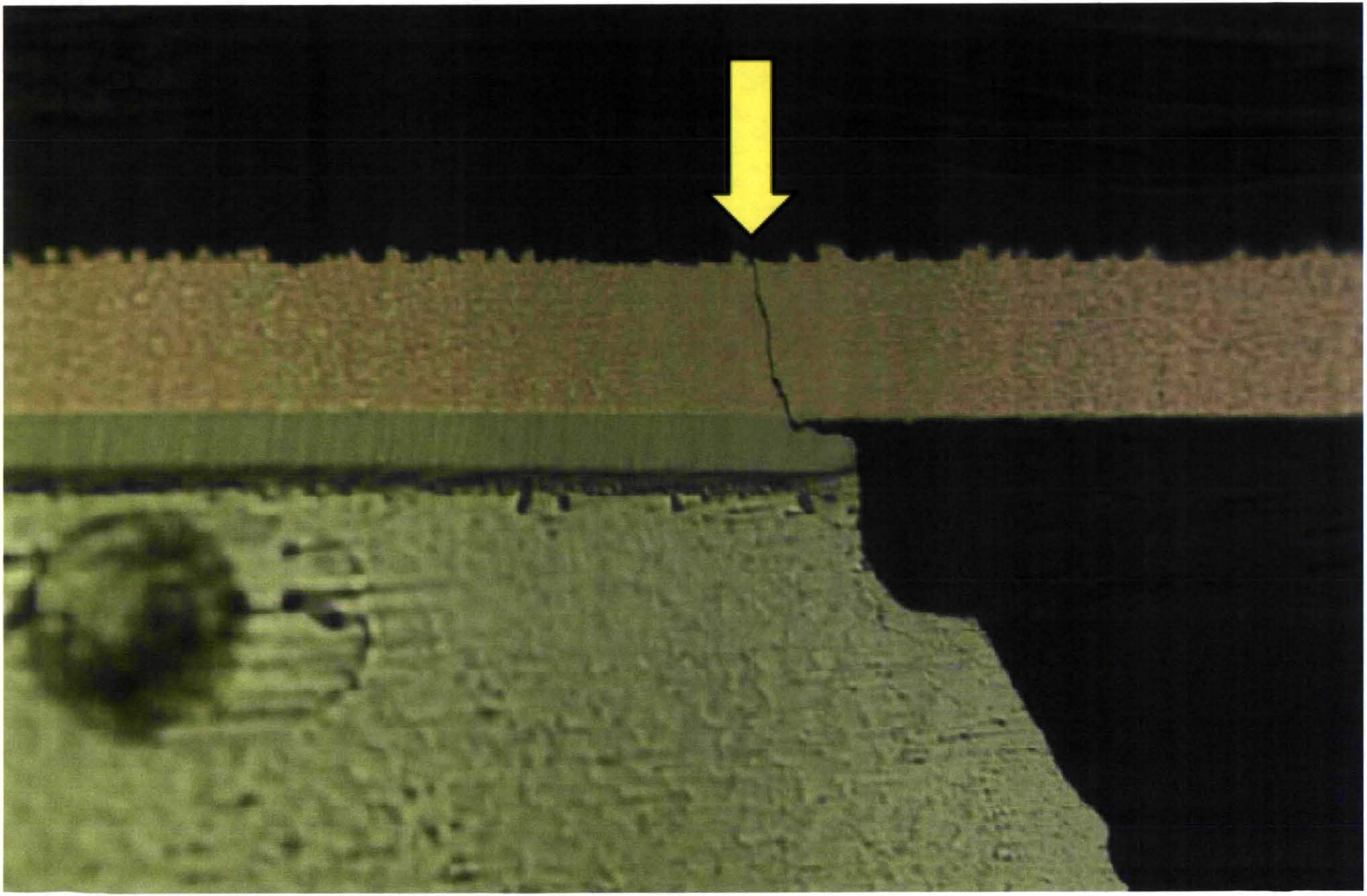
Vibration Testing

Test Vehicle 16 BGA U5 (SnPb Solder/SnPb Balls)



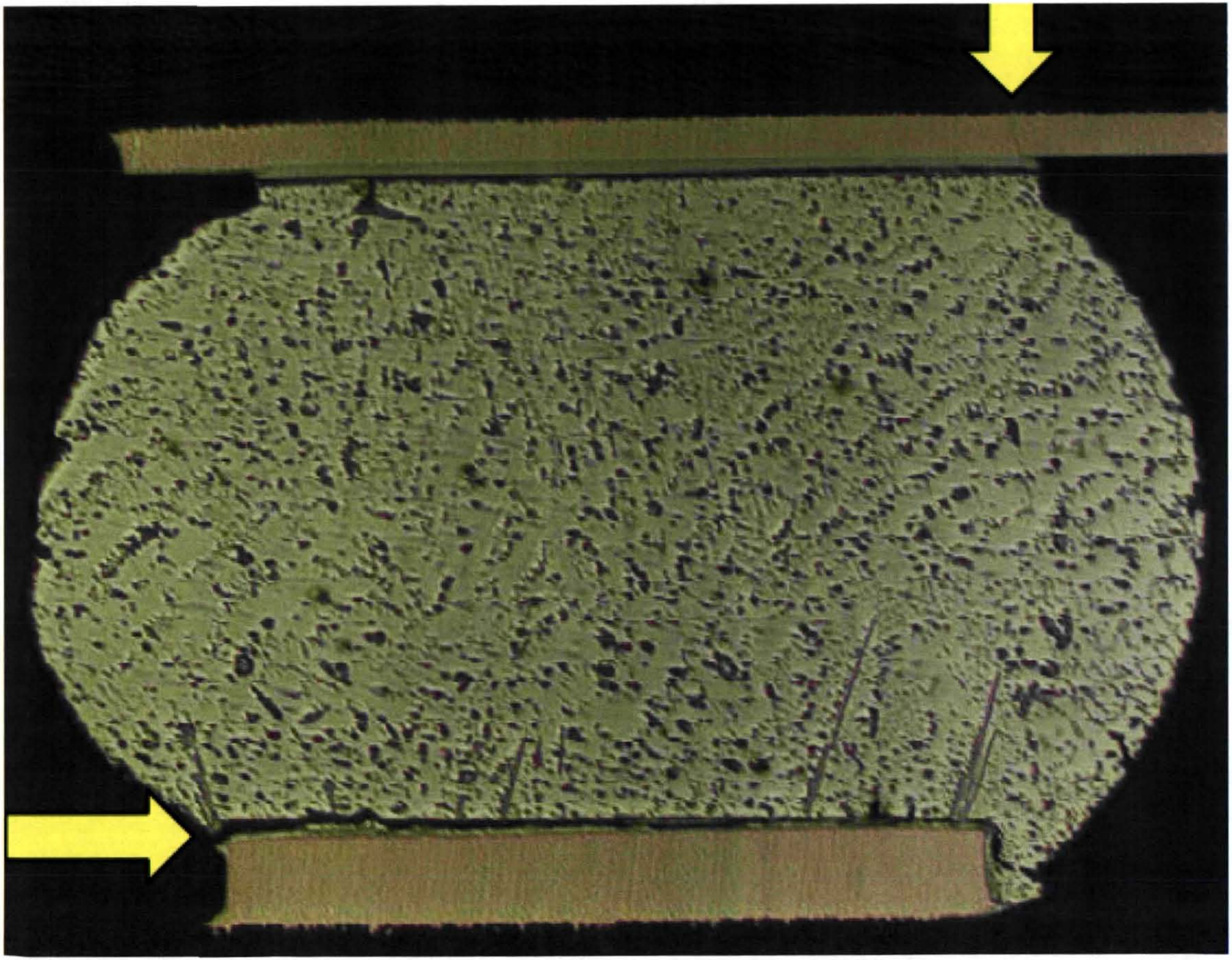
Vibration Testing

Test Vehicle 36 – Trace Crack on Component Side of BGA U21
(SAC305 Solder/SAC405 Balls)



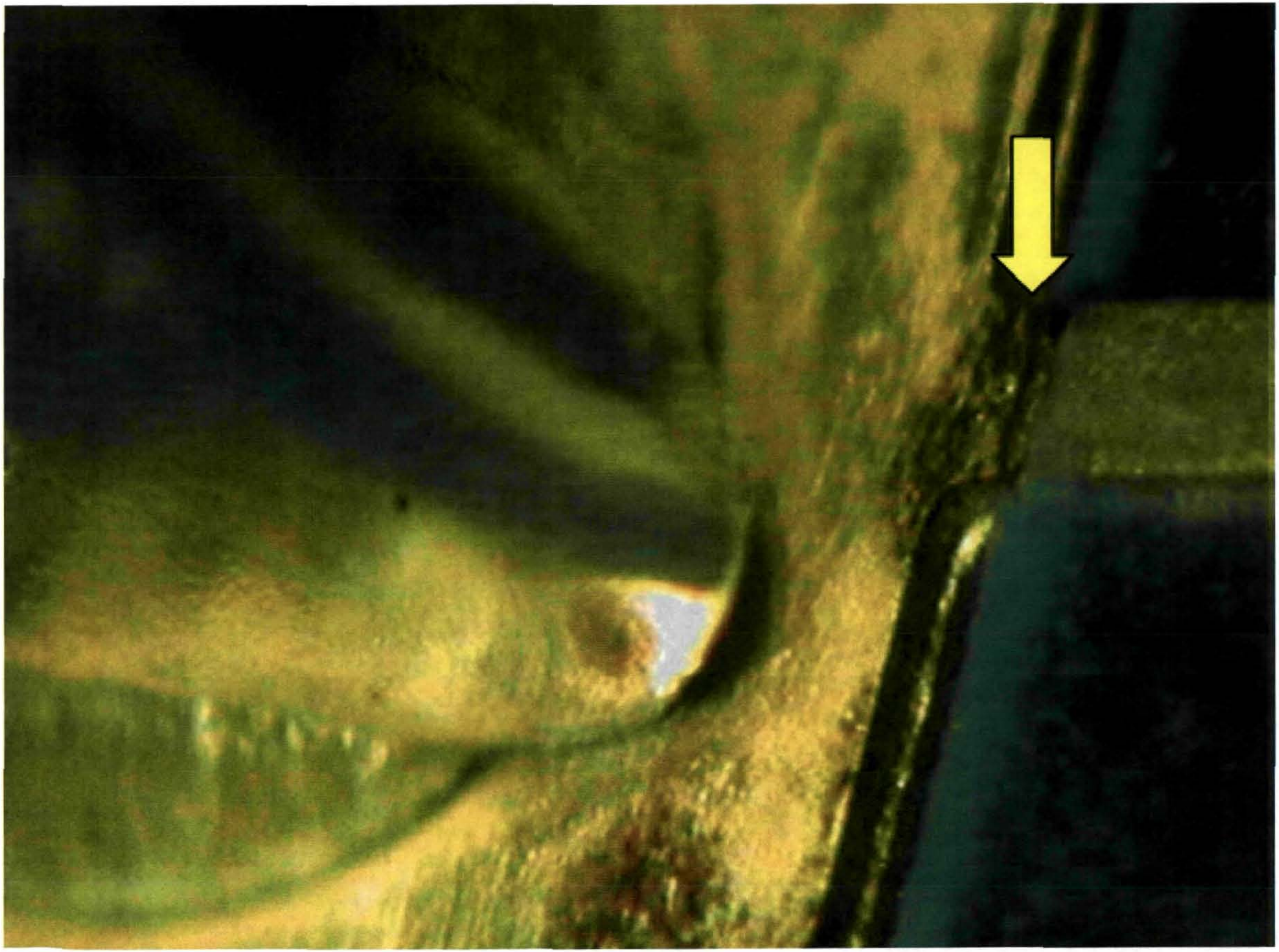
Vibration Testing

Test Vehicle 134 - Corner Ball of BGA U44 (SnPb Solder/SAC405 Balls)



Vibration Testing

Test Vehicle 112 – Cracked Trace at Corner of PDIP U38 (SN100C/Sn)



On-Going Failure Analysis

Mechanical Shock Test Vehicles			
Failure Analysis Location	**Test Vehicle**	**Component Location**	**Selection Criteria**
Sandia	153	U43	Look for cause of open
	153	U18	Look for cause of early failure
	153	U6	Examine solder mixing
	153	U11	Look for cause of early failure with special focus on trace cracking
	153	U51	Look for cause of early failure with special focus on trace cracking
NSWC Crane	189	U11	Look for cause of early failure with special focus on trace cracking
	189	U51	See if trace cracking is absent
	190	U44	Examine solder mixing
	190	U56	Look for cause of early failure

Drop Test Vehicles			
Failure Analysis Location	**Test Vehicle**	**Component Location**	**Selection Criteria**
Celestica	144	U4	Early failure - Cycle 1
	25	U4	Early failure - Cycle 5
	27	U5	Early failure - Cycle 3
	29	U6	Early failure - Cycle 3
	26	U56	No failure - Comparison
	77	U5	Early failure - Cycle 5
	187	U4	Early failure - Cycle 2
	92	U5	Early failure - Cycle 3
	59	U6	Early failure - Cycle 3
	58	U56	No failure - Comparison
	159	U4	Early failure - Cycle 2
	159	U44	Early failure - Cycle 2
	159	U6	Early failure - Cycle 2
	159	U56	Early failure - Cycle 4

Upcoming Event

SMTAI 2010

- October 24 - 28, 2010
- Orlando, FL - Walt Disney World Swan and Dolphin Resort

NASA-DoD Presentations - October 28

- NASA-DoD Lead-Free Electronics Project – Update
- Drop Test Assessment of a Medium Complexity Assembly for High Reliability Applications
- NASA/DoD Lead-Free Electronics Project: Mechanical Shock Testing
- NASA-DoD Combined Environments Testing Results
- NASA/DoD Lead-Free Electronics Project: Vibration Testing
- NASA DoD -55°C to +125°C Thermal Cycle Test Results

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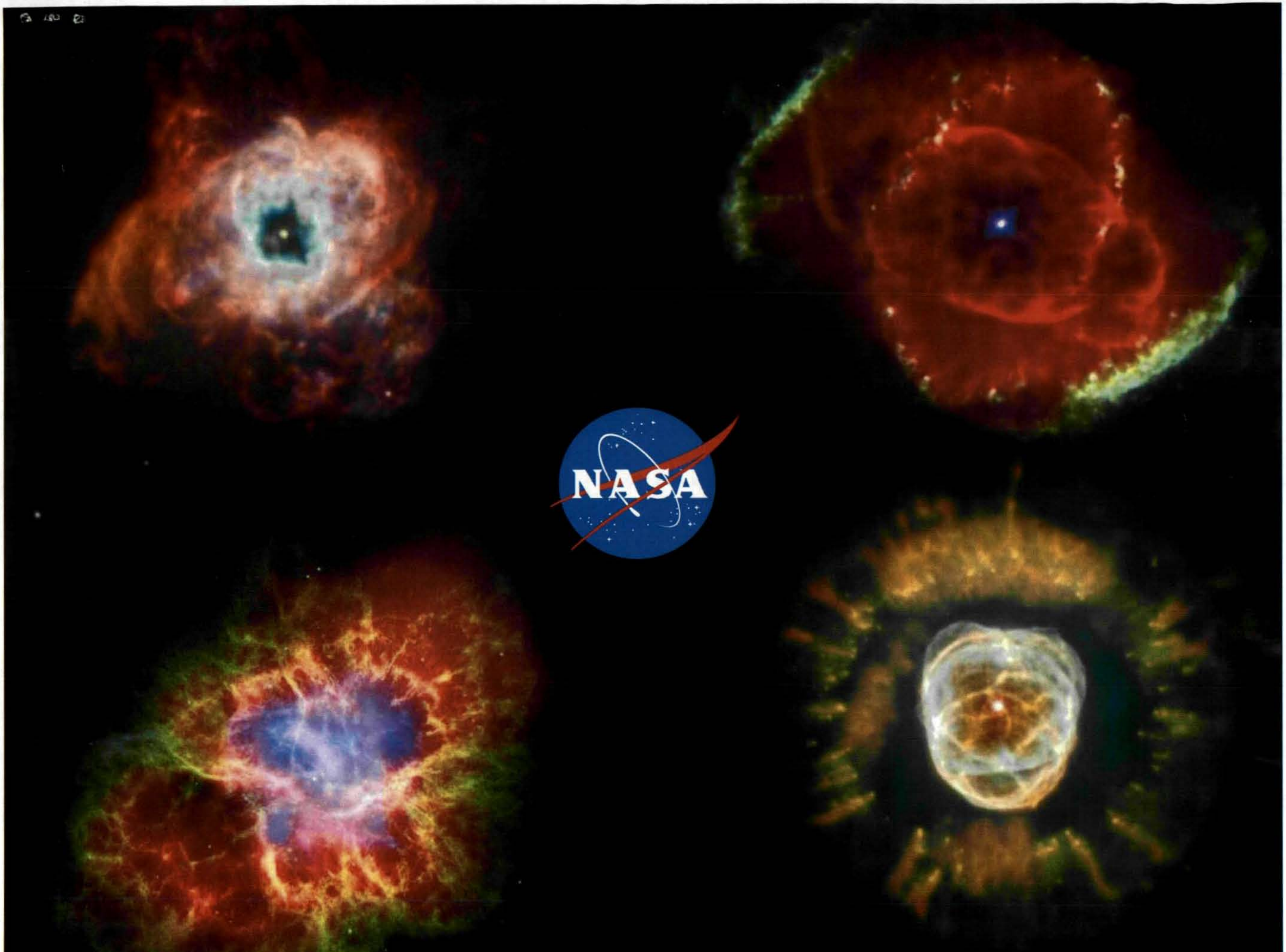
NASA-DoD Lead-Free Electronics Project:
http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html

JCAA/JGPP Lead-Free Solder Project
http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html


NASA